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MEANING OF SCIENCE IN SECONDARY SCHOOLS.

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I share with you the disappointment that I am sure you feel because Professor Coulter is necessarily absent from your meeting. It will be quite impossible for me to discuss this topic from the point of view that he would have assumed. He would have come to you as a student of one of the special sciences, and would have been able to discuss the meaning of that science, and the meaning of the other sciences which you present to high school students. The point of view which I assume in any such discussion is that of the student of education. It is my duty as an administrative officer to attempt to contribute to the organization of the high school curriculum, and to interest myself as fully as possible in the purpose of the various departments in the high school.

It is also my duty as a student of education to make as complete a study as I can of the results of different kinds of instruction in the secondary schools. From this point of view, I shall discuss the difficulties that appear in the administration of science in our secondary school program. I shall ask more questions than I answer, and I foresee that I shall be indefinite in my statements as to the mission of science in the secondary program. This is part of the misfortune which you suffer on account of Professor Coulter's absence.

One has very little difficulty when he encounters members of the Latin department, or members of the mathematics department in determining the place of their subjects in the school course or the methods which are appropriate in the treatment of these subjects. One encounters very little difficulty, because those subjects have been worked out very minutely. They have generations of tradition behind them and those generations of tradition have served at least to

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select the material that can be taken by secondary school students.

I think any new subject suffers the moment it comes into the curriculum by comparison with these traditional subjects, because the new subject has the whole process of organization by selection ahead of it. It needs to be worked over with a view to finding out what can be administered in the first year and what can be administered in the second year. Any new subject, I repeat—and it is true, not only of your sciences, but also of such a subject as modern languages—any new subject that comes into the course of study has to go over its own mass of material.

There is another point of view from which I think one ought to look at the difficulties that confront the sciences in the high schools. Even the traditional subjects, with all their experience behind them, are at the present moment having some difficulty in defining their own missions in the high schools, because we are in a period of very great and sudden change in two directions. In the first place, there has been a complete change in the character of our student body. One can hardly look into the various statistics of attendance of American secondary schools without realizing instantly that we have an entirely new problem, the creation of the last twenty years. Both the number of high schools, and the number of students have undergone astonishing changes during this period. In other words, we have brought into the secondary schools of the country a great body of new people, people with entirely different motives for attendance upon those high schools, or any other school, from the motive that prompted people going to the secondary schools twenty-five years ago. Some of these students are looking forward to business, some to the new professions. Taken all together, their aims are as manifold as the activities of the community. As a result the high school has a new problem, from the point of view of its students, and even those traditional subjects which have been regarded as settled in prestige and method are beginning to be questioned as to the missions which they must perform and may perform in secondary education.

In the second place, a very large body of new material has come into the course. In parallel with your own sciences, there are the modern languages and art and history. One

might go on and enumerate all those sciences which class themselves as "humanities." There are the economic sciences, and of course all of the practical arts. We have as a result a program that must be made up, for the advantage of the great body of students, and also we have a program filled up with new subjects, because new subjects are at hand. I think all of this creates an entirely new situation in the secondary schools of this country. It is a situation that might be described as paralleled by all our modern situations in business and civic life.

In the old days of pioneer communities, people set up their governmental relations somewhat gradually to meet new needs and one could see the government gradually evolving with the community; the community could try out this method of government and that method of government. People could meet together and could settle little difficulties as they appeared; the government could grow with the new needs of the community.

That is practically what we had in the early schools. The schools began on a very small scale. They began with limited material of instruction; they began with limited numbers of students, and those students were all of a very defined single type. At that time the program of the school could be solved gradually. That is why a traditional subject, like Latin, had relatively an easy time getting its material worked over, because the mistakes could gradually be eliminated, and the methods could be gradually worked out. That is why anybody could teach a course in Latin. That is why the material which has come down to us may very properly be described as "elegant pedagogical material." It is completely worked over, and is in such form that it can be handled by anybody who is at all competent to teach students anything. It was worked up by what our friends in animal psychology call the slow "trial and error" method. That type of growth which could go on in the pioneer community and in our primitive schools has passed. Here we have a great body of students; we have a great mass of new scientific material thrown in upon us—one needs not say to such an audience as this, at what rate this material is being thrown in upon us. Our problem cannot be solved by the slow process of "trial and error." We have a new situation in our schools; we have a new situation in our government. We cannot stop for civic institutions to grow up, as they grew up in

our pioneer communities. We have to have expert examination of the governmental situation, and I believe we need to have for like reasons expert examination of our school problems.

You cannot wait a single year; you cannot wait a single semester for physics, chemistry or biology to be worked out by any "trial and error" method. It is not possible for us to be at all complaisant in the presence of the hundreds of students who come into our secondary schools, and to say, "We can afford to make mistakes while we are putting this new material into the schools." We have a commission form of government, and we must put experts on the problem of arranging material for our schools, exactly as we put experts on arranging our modern commercial life, and as we employ experts in arranging our civic life. The time has passed when we can do things in a small, experimental way in any one of these walks of life. That is why it is proper, and that is the only reason, it seems to me, why it is proper for your executive committee to substitute on this program a student of education for a student of one of your sciences.

What is the difficulty with science instruction, when one faces it frankly? It is my business to study teachers with as much scientific machinery as my colleagues and I can invent for an examination of your characteristics. You who are here represent, only in a rough general way, the actual community that administers science. I shall attempt, however, to include in my discussion all science teachers. Among you and your colleagues I can find two general classes that, I think, are open to criticism. I have no doubt you would join me in criticising the untrained science teachers. We all of us know his and her characteristics. We all know the great difficulties that secondary schools the country over have in using such teachers to introduce the sciences. Here is a teacher that knows so little about a science that he can barely keep one lesson ahead of the class. A class is never fooled by that sort of a teacher. When you get a science teacher who is so limited in his comprehension of the subject that any new question that arises is postponed until tomorrow and postponed, frequently, with such a lack of frankness, that the class is perfectly clear as to the reason why it is postponed, you will find that the vitality has been taken out of science teaching. What you ought to have is a teacher

in science able to meet questions that arise in the minds of any vigorous class pursuing science. The situation in science is, I believe, a little different from the situation that presents itself in reference to the subjects where text-books are the chief means of instruction. You cannot raise as many new questions about Caesar's bridge as you can raise about the various facts of life and about the simplest physical phenomena. In science more than in any other subject the untrained teacher is sure to be found out. We have too many untrained teachers. I need not dwell on that phase of the subject, because I am sure you will agree with me.

I am a little in doubt whether you will agree with my next statement. I think there are some teachers who are overtrained in science—that is, I should say they are overtrained in a single science. I have seen teachers who knew a great deal about only one subject in science. They might be very good people in a large high school system where the school could afford to have one specialist dealing with each phase of science, provided these specialists worked under the guidance of somebody else. Please note all of the elements of the situation. That these specialists should be guided is as important as that they know their subjects.

I dare say you recognize the difficulty I am trying to point out, but I shall venture to recount one of my experiences.

I had the privilege of studying at one time with a man who had found the atomic weight of some substance—I do not remember now what it was. We had that atomic weight at every meal served. I am certain that my fellow student probably has the methods of getting that atomic weight as refined as they could be; I doubt whether they could be improved upon, and he doubted whether they could be improved upon. But that man could not talk about anything else. He was absolutely wrapped up in atomic weight, or whatever it was. He was so absorbed in that subject that I often wondered what he could do when he tried to teach.

That may be an extreme case, and yet I have seen that same sort of thing in schools. Suppose a man is so well trained in chemistry that when he begins to prepare a high school course he can see nothing but the demands of chemistry; he will ruin your school program.

When you get a specialist who is so absorbed in the one subject, you have from the point of view of the administrator

of a high school, a very serious problem. It is a problem of organizing a course of study for students with a man who has forgotten the students. One must organize a comprehensive succession of sciences extending through the high school, and you cannot get that done if you depend on a person who is trained only in one science. I am perfectly clear about that. It is easy to arrange a four-year course in Latin, because Latin is just Latin. You can arrange as many courses in Latin as you like, because they all run along in the same line. But who can settle the question about a four-year course in science, and who is going to settle it? Certainly not the overtrained science teacher. That is why I say, you will find persons who ought to be criticised, not because they are undertrained, but because they are overtrained in one direction. What we need is somebody who can take a sufficiently comprehensive view of science in our secondary schools to organize some sort of a coherent course in science.

The difficulty of getting a coherent course in science is the greatest difficulty which a layman sees. He goes to a science meeting when he has an invitation, and he hears discussions about how the sciences shall be introduced, and he finds little coöperation between the different kinds of specialists in science. He sees so little comprehension of the real school problem, namely, that of getting systematic work planned for four years; he finds it so difficult to get among the specialists in science any discussion of this problem, that he begins to be anxious lest specialization in science shall be the bane of our secondary education.

I have talked about the degree of training of teachers, and I have discussed the situation of undertraining and overtraining briefly. There is another type of difficulty which I have referred to above and shall now venture to elaborate. Science teachers are not willing to examine and discuss the needs of their students as a primary consideration in the organization of their courses. Science has a kind of inflexible logic of its own in the mind of a mature teacher, has a kind of coherency in organization that is so attractive that to break down this ideal arrangement in any wise or to criticise the typical arrangement of science material in any wise is very repugnant for the true scientist. I sympathize with this respect for the logic of science. I should be very glad indeed

if we could begin and go without any repetition in a coherent march through physics in such a way as to bring the student into exact knowledge and into precise forms of reasonings—I say I should be glad if that could be done, without leaving the path of logical order. But the fact of the case is that cannot be done; and I think we have all come to see that it is exactly what the earlier subjects accomplished through the "trial and error" method that we must work out in science. The earlier subjects came in with a mass of material, and they tried it and presented it to the students, and the students took it or did not, and little by little the available materials were selected and arranged. When we get first-year books in any traditional subject we get the benefit of that early experience. On the other hand, when you come to the sciences, there is, even to this day, the inertia which comes from respect for logic. Let us present science, says the specialist, in the order known to be the final order. I repeat, that you cannot do it, and it is my plea as a student of education; a plea to you who are specialists in sciences; let us get together and see that this material is in some fashion reorganized, and that you make it your business to study the students.

I do not know of any more productive study. In the University High School we are making an experiment in the teaching of mathematics. It is a radical experiment; some of you know about it. Mr. Moore suggested it some years ago. It is an experiment in combining algebra and geometry, and it leads to a good many difficulties which do not appear when you make the general statement that you are going to combine these two branches of mathematics with each other. We are trying to do the rational thing; we are trying as we go along to make a minute study of what is the effect of this combination in the training of students. We are taking certain routine work of the students and examining minutely this routine work with a view to finding out whether they get the algebra part of that work or the geometry part of that work more effectively and whether they get all the different types of each. It is astonishing how many different types of geometry you can develop, if you view it, not only from the mathematical point of view but from the point of view of the student. You can pick out the student who reacts readily to one sort of geometrical discipline and a student who reacts better to another sort. Why is that not a worthy prob-

lem for scientific study? Why is that not just as important a problem as the anatomy of the grasshoppers? Why is it not just as important a scientific problem to understand students as to understand the lower forms of life?

One of the members of this association undertook the same sort of analysis of the work of students done in the first year in our high school general science course. You can distinguish between observation and reasoning; and you can distinguish different types of observation. With these distinctions in mind, you can make a study not only of the material of your science, but you can turn your scientific acumen upon that more difficult problem, which is the examination of the students who are to learn the science.

I find too little interest in this kind of study and too little training to take up such study among secondary school teachers of science. Indeed, I may say that a like criticism must be made of secondary teachers in general. The teacher of the modern languages and the teacher of the classics as well as the teacher of mathematics and science, is too often neglectful of his duty to study the student. I find too little recognition of the fact that it is a worthy, intellectual undertaking for the secondary school teachers to study methods. In this respect secondary teachers are far behind the elementary school teachers. The elementary school teacher long ago recognized the fact that he or she knew enough subject-matter.

I want to interrupt myself long enough to say that I accept from no one criticism of this attitude on the ground that it does not emphasize subject-matter enough. I agree with the most violent advocate of subject-matter when he says that there are many teachers in the schools who ought to devote themselves more to the sciences they are teaching. I should not want, any more than you, an untrained teacher. But after we have agreed in praising subject-matter, I call your attention to the fact that elementary teachers have discovered that their fundamental and chiefest problem is the problem of arranging material so that it shall be acceptable to the children and educative in its character.

One does not need to know much about arithmetic to teach arithmetic in the first grade, but one must know a deal about first grade children. One does not need to know a great deal about arithmetic to teach second grade children, but one must

understand what changes have taken place in the intellectual development of those children as they have passed out of the first year arithmetic into the second year. That is the kind of problem that the elementary school teachers have discovered, and it is the kind of problem that we are going to investigate shortly in the secondary schools of this country. It is the problem of understanding that when you pass from the first year high school to the second year, and from the second year to the third year, you have made a great change in the type and arrangement of the intellectual material which you can offer your class.

Someone asked Woodrow Wilson what he thought of President Butler's statement that students ought to graduate from our American colleges at the end of the second year? His answer was, "Did you ever think of graduating a college sophomore?" I think that sort of an inquiry brings your attention to a type of fact which you must consider. Did you ever weigh carefully the possibility of accomplishing with a high school sophomore some of the feats we try? A sophomore is *sui generis.* He has as good a right to be studied as the amoeba; he has as good a right to be studied as the *pons asinorum.* The teacher who goes flippantly into a sophomore class in high school, believing it is a mere class in science instruction, has not the training for that work which he ought to have, and has not the training that we shall be demanding very shortly, before we let him experiment with a sophomore class. You would not let an untrained person go in and use some of your apparatus; we shall come to recognize, sooner or later, that we have apparatus in the desks as well as on the lecture desks. When we recognize the fact that it requires as much training to manipulate these mental machines as it does to manipulate some apparatus set before students for the purpose of instruction, we shall make more rapid progress in science instruction.

May I occupy a few moments more in offering you some suggestions about investigations of the type I have been trying to advocate. The first question I should suggest to you is the question of the different types of interest which appear at different stages of intellectual maturity. Mr. Finlay, under the general guidance of Dr. Caldwell, made such an investigation in our elementary school.

May I digress to say that I believe you will never solve

your problem of science in the secondary school until you have solved the problem of science in the elementary school?

Mr. Finlay's investigation was made in the elementary school. He raised a question that is supposed by many to be answered. That question is, "What kind of scientific interest do the pupils exhibit in the different grades of the elementary schools?" You can find it written down in all of our pedagogical discussions, and journals of science, that you should first study animals and plants; that you must progress slowly to the formal sciences of physics and chemistry. Mr. Finlay took two or three kinds of science material into our elementary school in the ordinary routine of nature study instruction. He took into the class an interesting animal, an interesting plant, and a rough pendulum. He demonstrated these and then let the pupils ask questions about them. Later he asked them to write a description of what they had seen. The only result I want to point out is that the pendulum did not suffer by comparison with the animal and plant. Why? I think the answer is that this swinging pendulum presented a compact, easily analyzed phenomenon. When you present that sort of thing children like it, because they can comprehend it. A child can be baffled by zoölogical information thrown at him. He can be as much confounded by that as by any mathematical demonstration in physics. The trouble is that we have allowed ourselves to believe that it is intricate analysis that characterizes physics. You cannot begin with that. You have to begin with something that works easily, something that works simply. Those children were making pendulums after Mr. Finlay had shown them one.

My discussion of the subject, "The Meaning of Science in Secondary Schools," has been for the most part negative. I do not believe that science in the secondary schools ever will perform its proper mission until those who are the custodians of that branch of learning have worked it over in such fashion that it can get into the minds of the secondary school students. So long as it hovers around the outside of their minds, even though it may be perfectly clear and lucid in your own thinking, it has not very much of a mission except to earn your own salaries, and for that purpose it is not of great value to many of the students who pass under your care.

I have spoken of science for the most part, but much of

what I have said applies to mathematics. Algebra is one of the greatest sources of retardation and elimination in our schools. A student who is confronted in his first year with Latin and ancient history, and the usual type of algebra, has a grievance against our civilization. What we need, and what we shall get shortly, is some reorganization of our algebra and geometry.

To come back for a general recapitulation of what I have tried to say. I have heard teachers remark complaisantly, "Why, science will work itself out." But we are not in that kind of an age at all, either in business, government, or school life. We cannot wait for science to work itself out, as Latin did. One can go back and read that long and dreary history of medieval secondary education, and see that the business of these schools was primarily the training of Latin teachers, not of the pupils. The teacher cannot enjoy that indulgence in modern life. The modern community is unwilling to experiment for the purpose of training teachers. The community is impatient with the failures in science instruction. Why do these failures appear? Because scientific material has not been organized, because such associations as this find it extremely difficult, when they come together, to determine with definiteness what science ought to be given in the first year, what science ought to be given in the second year. There are plenty of people who know physics and chemistry, biology and botany, and what not, but there is a painful minority who know enough in general of all of these sciences to comprehend what we people who come to you from the administration side and from the lay side of this school situation, are trying to urge upon you—the necessity of a four-year course in science, or something like two coherent years in science. Is it not possible for you to get away from physics and chemistry and physiography long enough to study the abilities of high school students?

It is an interesting fact that you are brought together under that general term, "Science," recognizing a common interest in spite of the diversity of interests included under that general name. Why do you group yourselves together thus? I think it is because all of us feel that there is, somehow, a single problem back of all these special lines of instruction. There is a single kind of opportunity which you have that is different from the opportunity of those who teach the hu-

manities and literary subjects. There is something, vague and general though it be, which we have a right to call the scientific method, and which is so characteristic of our modern life, so important to every student who goes out from the secondary schools, that there ought to be sciences in the secondary school course. So much we all hold without the slightest reserve, that you have one of the greatest opportunities in secondary education; that you have one of the largest opportunities to introduce a body of new material that shall revitalize the middle school which is the center of our educational system. If you are to succeed, I believe it will be because you turn about and face not only the specific problems of your own particular science, but that great general scientific question, the question of the organization of your material. This question involves a minute and careful examination of your students as well as your subject-matter.

ON THE TEACHING OF MATHEMATICS TO FRESHMEN ENGINEERING STUDENTS.

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In rapidly growing universities where colleges of engineering are established, the teaching of mathematics to freshmen students, especially those electing technical courses, can easily drift into a very unsatisfactory condition. The number of students registering for the courses in freshman mathematics, which generally include college algebra, trigonometry, and analytics, whether taught separately or correlated, has been constantly increasing and the engineering majors form by far the greater part of this number. The problem of satisfactorily giving instruction in mathematics to this class of students is now being worked out in more or less detail by the special committee of mathematicians and engineers formed three years ago, whose particular purpose is to investigate the larger problem of mathematics for engineering students. Their recent preliminary report, covering also the mathematics of the sophomore engineering student, should be studied carefully by all instructors having such classes in charge. However, even much study of any report will lead to little or no result unless the instructor has definite notions and aims concerning the field in which he is working and the courage of his convictions in carrying out his plans. This should apply as well to the department backing the instructor and to the university backing the department. Have all these considered the problem worth while or even recognized it? Do they know what it means? Fundamentally the solution is easy and I instance the case of Stanford University, where the department of applied mathematics has given it serious attention for some time. Reduced to first principles it is a question of whether or not the institution and its departments or colleges think it worth while bestowing upon the freshman student the attention due him, an amount at all commensurate with that given, say, the graduate student. Viewed from another standpoint it is a question of the highest efficiency all along the line, for the freshman as well as the senior or graduate student—whatever is worth doing is worth doing well. Does the institution believe in

this policy or, if so, is it carried out only in resolutions which reform much but too often entirely on paper!

How are universities solving the problem to-day? We have all seen the professor whose interest lies chiefly in research in pure mathematics "doing duty" with a section of twenty-five or thirty freshmen or sophomore engineering students in the same frame of mind as the man who, though he "didn't like crow, yet he ate crow." We have, perhaps, heard him say frankly that he wasn't interested in the problem anyhow, but that the sections must be taught somehow. We have seen such a course conducted by the lecture method entirely and the whole emphasis placed on abstract and rigid proofs, a method not at all suited to the needs and capabilities of the students and removed as far as possible from the recommendation of the committee on engineering mathematics, which says: "The main part of the work of such a course should be problems done by the students—each problem being solved on the basis of the small number of fundamental theorems here mentioned." The existence of such a condition of affairs is deplorable from the viewpoint of either the professor or the students in his sections.

If the situation just outlined is deplorable, what can be said of that where the majority of the sections, at least of freshmen engineering students, is in charge of assistants or fellows in the department of mathematics! Their tenure of office is short, their experience in teaching limited, their special training to handle the problem none, and their main interest in the lectures on their advanced work toward their degrees. Luckily for the freshmen, there are among these men those who in their enthusiasm to make good also in their teaching will develop in the student the same enthusiasm in his work, even though the whole problem of his instruction in college mathematics may be handled with efficiency in spots only.

Perhaps it may be argued that there is no problem; that anybody having had a reasonable training in mathematics is capable of handling the freshman work, and too often is practice based on this assumption. The college of engineering or its equivalent has a right to demand a different attitude toward this work. We believe that there is not only a problem well worth while but that it is worthy of a doctor's thesis on the pedagogy of mathematics.

Let us see the nature of the material upon which the instructor is to work. Undoubtedly, the students attending college are, as students, the best that are graduated from our rapidly growing high schools. Let us "size up" a few types as they come to us. They are in general enthusiastic in their work, in which particular we seem not to agree with the somewhat pessimistic strictures recently passed upon college students in general. They may not be exactly certain of the choice of their profession but they certainly have a wholesome respect for engineering as a career. We have, first of all, a small percentage of students poorly prepared in their high school mathematics, especially algebra. These slipped through their courses carelessly, their high school instructors were easy on them, anything went, and the students received their credits for admission to the university. As an extreme case I mention one where the student had the official stenographer of the secondary school fill in for good measure grades on several subjects he had never studied—and the principal signed the report. However, students of this type are not numerous and the department is fortunate which can weed them out in the first few weeks of the course. Especially well can this be done for the department of mathematics if college algebra is the first course offered in the freshman work. A brief review of elementary algebra will suffice to show up those who "beat the game" in some way or other. The results of two years' trial of this process at Stanford University show that about ten per cent are of this type. Care should be taken to "size up" the men carefully and allowance made for those whose preparatory work had been done some time before, and who were in consequence "rusty" in their algebra. High school instructors of mathematics would hardly care to hear in detail the summing up of the evidence which these men give and their statements concerning the reasons for their poor preparation. Let us eliminate these from the discussion with their elimination from freshman classes in mathematics. There is an added problem on the hands of the department of mathematics in institutions where such a weeding-out process would not be allowed.

We have as another type the high school graduate who, under indulgent teachers, seemed bright in his mathematics. It is a case of overconfidence and false standards in his case and he wonders why he doesn't lead his class as before. He forgets

that there is more competition and a faster rate of progress. His failure to attain the false standard he formerly had may discourage him or even put him out of sorts with college mathematics. His case remains for a time at least a problem for the instructor to solve.

Again we have the business college student who writes well, flourishes his letters, and shades the capitals well. He may even have taken a so-called collegiate course in an institution where degrees are granted when so many courses are paid for. Invariably he thinks he knows much, and it is often a problem to get him on a rational basis where he works efficiently, and where superficial work is at a discount.

There also presents himself the student who wants everything to be intensely practical. He likes his rules ready-made and wishes so to apply them. It may be a difficult problem to get him to appreciate a fine bit of theory, but it certainly must be impressed upon him that he is attending college not for the sake of simply getting formulas and attaining an ability to apply them. Rather is he to get at the fundamental truths of the science and not to accept blindly definite rules of procedure outlined in texts. He must be taught to get the fundamental laws, for the engineer must not only know the theory but know it so well that he is able to use it. And I distinguish clearly between theory and abstraction and choose in favor of the former. If the student has done practical work before entering college it is well and his point of view is worth knowing. The instructor should be able to appreciate the same and go him one better by showing him where he may employ the finer processes of mathematics to problems which so far he has solved by rule of thumb.

Rarely does there appear a student with a decided analytic trend of mind. A student of this type will ask to have things expressed in equations or symbols, after which it means more to him than if illustrated by a figure. He is apt to be visionary and to emphasize abstraction above theory and application and generally lack in ability to use his mathematics.

On the other hand there is by far the majority with a geometric turn of mind. A student of this type will want to see how things look when illustrated and he may waste much time while his geometric intuition is at work gathering the facts of observation, but he will be sure of his theory when

his conclusion is reached because he has seen it from another point of view. Definite and concrete results are easily obtained from this type. He may be a man who letters and draws well, perhaps has worked some around a drafting office, perhaps may not get beyond simple geometric considerations. He may even do a piece of work which grades one hundred per cent on looks and arrangement and miss the point of the whole problem a mile—or more.

There is the slow man, the plodder, who always works twice as hard as most men, whose grades will always be just about so good but no better; but he always responds to an effort made in the interest of his welfare.

We have also the natural born loafer, who soon finds out that mathematics is honest and returns results only after effort; he soon feels it not worth his while to do the strenuous work required and the college of engineering knows him no more. He will generally find an easier berth in some other department. We have the sloppy man whose work, however good, never shows up for its full value, and who seems totally incapable of making a decent figure to accompany a demonstration. And the careless man is always with us. Extreme cases of this type have been known who would just as soon say $(x+y)^2=x^2+y^2$ and $\frac{1}{a+b}=\frac{1}{a}+\frac{1}{b}$ as not, and when such exhibitions are made the instructor will think as Holmes says: "It may be questioned whether anything can be conscious of its own flavor. Whether the musk deer, or the civet cat, or even a still more eloquently silent animal that might be mentioned, is aware of any personal peculiarity, may well be doubted."

But let us not forget the well-trained student from reputable high and preparatory schools as well as those which come from technical and manual training high schools. His grades may be accepted at par, the gleam of intelligence is in his eye, and he soon works efficiently because he has had previous training in the application of fundamental principles, and he knows them so well that he feels sure of his ground. He will reason intelligently, present his views clearly, and, if necessary, set the instructor right in case he errs in the details of the presentation of a subject. This type is becoming more and more the prevailing one and it may be asked: "Why not work for this type alone?" Too often do instructors take this point of view—because it is the easy way out. On the other hand, is he doing

his full duty when he works according to this plan? Certainly his ideal of the teaching profession is not the highest and he certainly takes a narrow view of the problem of college freshman mathematics. If he drops out the human side of his work he will certainly fail in efficiency and deserve the condemnation he receives—if not from the department or faculty, then at least from his students.

And what should be the aims of the instructor, and what may he hope to accomplish? Pedagogically and technically it is a question of welding into a homogeneous mass the material which presents itself. It will always be impossible to do this completely and it is well that limitations exist, yet the general process remains the same. It might be argued that in this process there is the danger of destroying the individuality of the student and this would be unfortunate unless the individuality were a menace to efficient work. We have all of us seen in our sections pronounced types of individualism whose sole cure lay in the drastic and energetic methods applied at times by upper classmen, and would have welcomed the application. We would rather approach the problem from the standpoints of "smoothing off the rough corners" and of efficient work.

What shall be the test of efficient work in the freshman courses? As far as content of courses is concerned certain agreements can be reached and these include the essentials as given in most of the standard texts on college algebra, trigonometry, and analytics. "The main part of the work of such a course should be problems done by the student—each problem being solved on the basis of the small number of fundamental theorems here mentioned." This should always form the backbone of any course.

The ability to handle the men so that they are working efficiently at all times is much more difficult. It is by far a greater problem to handle them in this manner than to present a course of lectures illustrated with examples worked before their eyes, while the students take a fleeting note or two. The interest in the work varies directly with the success which the student has in keeping his head above water. These broad general rules apply throughout.

There are many aids toward securing this efficiency besides the fundamental one which hinges on the personality of the instructor and his interest in his work. Suppose we look at the actual work of the engineer and note the rules which apply.

In the first place the engineer's work must be done in a reasonable time, for time means money in actual practice. So with the student; he should learn to concentrate his efforts toward definite ends and thus secure results. The practicing engineer must show results or else his services are not valuable. Not that this principle should not be applied with a view to the capabilities and individualities of the students, yet, nevertheless, they must produce results. The conclusions reached should in all cases be definite and clearly stated, and a constant watch over the ability of the student to use fairly decent English is well worth while. Practical problems from the field of engineering practice will always arouse interest.

A further inquiry into the habits of engineers will reveal the almost universal habit of illustrating their work by means of suitable figures drawn to scale. This is a habit difficult for some students to get, and yet there is no greater aid than this in helping him develop that "horse sense" necessary for a successful career as an engineer. The intelligent and universal use of coördinate paper throughout the year will develop in a student an ability to illustrate his thoughts and conclusions which will stay with him to the end of his course. And this constant use is about the only method which gets the results desired.

In all engineering work "checking up" is of primary importance. Few pieces of work of importance are carried out on the authority of a single man who may originate a design, but all computations are checked carefully. Instructors of engineering students may easily learn the lesson this teaches. There is no valid reason why the first-year student should not use the slide rule and planimeter in checking up the results of his computations, for such must be made continually. In engineering practice these results are generally obtained correct to a certain number of decimal places or significant figures. This same point of view should not be lost sight of throughout the course. The intelligent use of tables and other aids mentioned is certainly a valuable by-product. The student should be taught to rely on his conclusions, generally given in the form of definite results, and to gain the desired confidence he must be sure of his work to the desired decimal place. His mathematical conscience will be developed in proportion to the accuracy with which he works. He should also have an independent judgment on the degree of refinement of mathematical processes required, for approximations enter into the daily life of the engineer;

but it is not always necessary to work for, say, the sixth decimal place.

The student's ability to express himself in well-chosen, terse English should be developed. In order to express himself thus it is necessary that he have the subject-matter of his problem well in hand. It will be found that this ability will also grow only with practice. A year's training in the use of correct expressions will do for his English what the requirement that all of his written work shall be high grade will do for his ability to organize his results, and both are essential.

But, it may be argued that any student should go through the process prescribed for the engineering student. Well and good; certainly there can be no objection; the only point of difference is that to the engineer it will sooner or later be a matter of dollars and cents, to say nothing of promotions. Every engineer will sometime or other be called upon to use all the by-products, and it is our opinion that systematic training toward the desired end should begin early in his course.

Some men have questioned whether or not this aiming for efficiency might not tend to destroy individuality and make the students all of the same pattern. To this we might answer that no harm would be done, provided the pattern were a good one. This it can easily be if a high standard is maintained. And such there should be. Students will appreciate it and feel a great satisfaction in doing well things worth while; there will be interest in the work and no one kept from developing to the extent of his capabilities. The stimulus to both student and instructor is great; and, when a course is completed, each will say to himself: "I have done so much well, and it has been worth the effort. I can see where it leads to larger problems in wider fields."

MATHEMATICS IN NORMAL SCHOOLS OF GERMANY AND SCOTLAND.

By William A. Austin,
State Normal School, La Crosse, Wis.

Mathematics in normal schools in many sections of this country is still a problem; no very satisfactory solution has been obtained. In connection with our efforts to offer desirable courses in mathematics and to make a wise selection of subject-matter to be taught to prospective teachers, a critical study of the work outlined in this subject for the normal schools of Germany and of Scotland may yield many valuable suggestions. It is not difficult to discover pedagogical principles and methods interwoven with logical organization of subject-matter in the scheme of either country.

The German normal schools have a five year course. The first three years of this course consist in an elementary or preparatory course. Students who have completed the work of the elementary schools in a satisfactory manner and who desire to become teachers enter this preparatory course. There is very little break between the work of this three years' course and the final two years' work. A large per cent of the students remain in school continually throughout the five years, and many of them live in a dormitory connected with the school. The unit of work is the hour. School is in session six days per week, and a few recitations are conducted in the evening. A week's work consists of twenty-five to thirty hours.

The annual report of the Kaiserslautern Normal School of Kaiserslautern, Germany, is before me; and the following translation of the work outlined for arithmetic and mathematics in it is given in some detail:

ARITHMETIC AND MATHEMATICS.

First Year. (Four hours per week throughout the year.)

Arithmetic: Number, decimal system of writing numbers, Roman notation, prime and composite numbers, factors, factoring, drill in composite numbers from 1 to 1,000, highest common factor, least common multiple, the four fundamental operations, weights, measures, money, time, resolution and reduction of denominate numbers, common fractions and the decimal system of writing decimal fractions.

Second Year. (Four hours per week throughout the year.)

Arithmetic: Common fractions, decimal fractions, short-cut methods for the fundamental operations, ratio and proportion, percentage, gain and loss, commission, interest, notes.

Third year. (Four hours per week throughout the year.)

Arithmetic: Aliquot parts and problems of review.

Algebra: The four fundamental operations with whole numbers and fractions and the solution of simple equations.

Fourth Year. (Three hours per week throughout the year.)

Algebra: Equations of the first degree with one and two unknowns; positive, integral powers and roots; quadratic equations; problems for algebraic solution.

Geometry: Problems of geometric construction; most important theorems; fundamental notions of angles, parallel lines, congruency of triangles, circles, equality and areas of plane figures.

Fifth Year. (Three hours per week throughout the year.)

Algebra: Ratio and proportion, powers and roots, imaginary and complex numbers, survey of the development of numbers, solution of algebraic review problems.

Plane Geometry: Similarity of plane figures, theory of the circle, regular figures, problems.

Solid Geometry: Important theorems on relative positions of planes; general properties of prisms, pyramids, cylinders, cones, and spheres; computation of surface, area, and volume of the cube, prism, pyramid, cylinder, cone, and sphere; problems.

It is interesting to observe that mathematics in some form is taught each year of the five years; that arithmetic is the main line of study during the first three years; that algebra is presented during the third, fourth, and fifth years; and that geometry is spread over two years' time. Notice the opportunity for gradual, well-graded, and certain growth in mathematical knowledge, in power of thought and coördination, and in strength to use information.

There are two distinct courses of study for the training of teachers provided in the Scottish educational ladder, the Junior Training Course and the Teachers' Training Course. The Junior Training Course, consisting of three years' work, is given by over one hundred and twenty schools of the higher grade type. Students enter this training at the age of fifteen years, after completing a three year course in the higher grade classes. The Teachers' Training College offers a two year course of study for students in full training to graduates of the Junior Training Course, and of the sixth year course given by the higher grade schools. There are four of these schools for teachers in full training; each is connected with one of the large universities, so that students who are taking this two year training may pursue work in university classes at the same time. "Thus the academic narrowness that is a danger in independent normal schools has been avoided."

From a "Syllabus of Work" given to Junior students in the Boroughmuir Higher Grade School and Junior Training Center of Edinburgh, Scotland, the following copy of the outline in mathematics is taken. This work is accomplished in seven recitations per week throughout the three years of the course:

MATHEMATICS.

First Year.

1. **Arithmetic:** Including practice, proportion, percentage, square root, simple interest, the metric system, vulgar and decimal fractions.

2. **Algebra:** Including fractions, factors, square root, equations of the first degree, simultaneous equations of the first degree, easy quadratic equations, easy quadratic surds, problems leading to the above.

3. **Geometry:** The subject-matter of Euclid, Books I, II, III, and IV, with easy deductions.

4. Trigonometry: Measurement of angles, circular measure of angles, trigonometric ratios, easy identities, problems in heights and distance, solution of easy equations.

Second Year.

1. Arithmetic: As in first year with compound interest and logarithms.
2. Algebra: As in first year with quadratic equations, surds, indices, cyclical order, symmetric functions, etc.
3. Geometry: The subject-matter of Euclid, Books II, IV. and VI.
4. Trigonometry: Ratios of angles of any magnitude, variation of functions, graphs, the triangle formulæ, solution of simple triangles.

Third Year.

1. Arithmetic: The whole subject. A review.
2. Algebra: As in second year with ratio, progressions, and proportion.
3. Geometry: As in previous years together with the elements of solid geometry.
4. Trigonometry: To solution of triangles.

One of the four schools for teachers in full training is located at Glasgow, Scotland. This training college provides the two year course and permits students to enter class work in the University of Glasgow. The Glasgow Provincial Committee for the Training of Teachers governs the school and plans the courses of study. From their "Syllabus of Subjects," which is before me, the main points of the outline of work in mathematics (and methods), which is too long to copy, is given below. This material is covered in three recitations per week during the first year and one period per week during the second year. This course for teachers in full training corresponds favorably to our two year courses for high school graduates.

Mathematics (and Methods).

The course is intended to be, at every point, suggestive to teachers. The methods of presenting the subject are precisely those the student teacher is advised to use himself. The principles of arithmetic are carefully and fully discussed. Demonstration lessons are given frequently. Emphasis is laid on mental arithmetic, on the importance of making mentally a rough forecast of the result, and on checking the answer.

Some of the topics are: numeration and notation; other systems of notation and exercises on scales of notation; a scientific study of the four fundamental operations; factoring; prime and composite numbers; greatest common factor; least common multiple; common and decimal fractions; ratio and proportion; measurement of length and area; squared paper used in finding areas; areas on maps; the planimeter; inscribed and circumscribed circles; division of lines into proportional segments; the vernier and its use; similar figures; use and construction of scales; solution of problems by drawing to scale; elements of solid geometry; the trigonometric ratios of an angle; measurements of heights and distances with a simple theodolite, the results being worked out by drawing and by calculation; the sun's

altitude by measurement of the length of the shadow cast by a vertical rod; mathematical tables and logarithms in calculation; use of slide rule; algebra treated as generalized arithmetic; graphs; interpolation; the gradient of a curve; graphical methods of solving equations; simple exercises in factoring and algebraic solution of certain types of equations.

In these outlines of work taken from the Scotland normal schools our interest is aroused by the amount of time devoted to the subject and to the continuity, coördination, and scientific development of the subject-matter. At least two fundamental principles upon which these courses of study are based are obvious: first, education is a process of mental growth in which time, thought, association, and reflection are essential factors; second, there is a natural unfolding of a subject-group, in which the subjects making up that group *walk* side by side, arm in arm, each aiding and supporting the others.

Education, to the Scotchman, is an internal soaking-in process. They believe there is such a thing as the correct mastication, digestion and assimilation of educational food as well as of physical food. No well-defined boundary lines between subjects can they see. The branches merge into each other, overlap, and thus form a network of material for study. The Scotchman cannot see, for example, where arithmetic leaves off and algebra begins, where algebra leaves off and geometry begins, nor where geometry leaves off and trigonometry begins. Their plan of work is based not so much on the spirit of the spiral method as on what may be called an enlarging concentric circle method. The student teachers in these schools certainly receive substantial academic, scientific, and pedagogical training in the subject of mathematics.

USES AND ABUSES OF "SCHOOL HELPS" IN THE TEACHING OF ARITHMETIC.

BY A. KENNEDY,
Weyburn, Sask.

There is need of a change in the teaching of arithmetic; this is asserted by business men and admitted by teachers of mathematics at the various conventions; and the need is clearly evidenced by the eagerness with which teachers just out of the normal schools look for help.

The particular purpose of this discussion is to examine one of the sources where help is frequently sought. The "School Help Series" includes a book dealing with primary arithmetic in which we find:

"LESSON 1.

"Distribute slats (one to each child). Let the children 'pretend' to go to sleep. At the call 'Awake,' all at once are interested.

" 'Who came to see you sleeping?'

" 'A slat, a stick.'

" 'Hold slat in right hand.'

" 'How many slats have you in the right hand?'

" 'One slat.'

" 'Place on the table one bean, one pebble, one slate, one book,' etc. 'Show me one finger,' etc. (object being to accumulate instances).

"Teacher then places figure 1 on the blackboard, the written character representing the idea. Children make it on their slates. Tell them that it represents one stick, one slat, one flag, one top, one marble, etc. Impress upon them the fact that 1 always means one something, so that they will recognize the written symbol for one.

"N. B.—Form of figures might be made interesting by comparing them to different objects; '1' stands straight like a good soldier."

Are the children interested at the call "Awake"? Is it not an insult to the intelligence of any child to teach him the thought "one"? Why should there be the "object to accumulate instances"? Is the object not the teaching of the thought "one" rather than the calling attention to the objects?

Does "1" represent one stick, or one slat, or one flag?

"LESSON 2.

"As before, give another slat to each child.

"Hold first slat in right hand.

" 'How many in right hand?' 'One.'

"Hold second slat in left hand.

" 'How many in left hand?' 'One.'

"Transfer left hand slat to right hand.

" 'How many ones in right hand?' 'Two ones.'

" 'We call the two ones by the name "two." '

"Show the form '2' (like a little duck in the water).

"Let the children make the figure on their slates.

"Make them understand that figure '2' stands for two somethings."

Are the two somethings the duck and the water? Teach the child in this manner to-day; to-morrow place "2" on the blackboard and ask the pupil what it is. Will he think of two objects? I would expect him to speak of the little duck in the water.

"Numbers three to five. Proceed in a similar way.

"It is important that from the first children should be trained to make correct forms of the figures. Perfect figure formation is just as necessary as perfect letter formation. It is very difficult for little ones to make some of the figures properly, as many children have a tendency to reverse the forms of some. To obviate this a little story connecting the form of the figure with some object children have seen will fix the impression better; for example:

"Have the children make two apples— O O

"Tom takes a bite out of his—)

"Nell takes a bite out of hers—)

"This is how the apple looks—))

"L is a chair with a perforated seat.

"Roy put a darning-needle through one of the holes.

"This is the chair— L.

"This is the knitting needle—/.

"The chair and the knitting-needle looks like this—4—figure 4.

"Make a row of 5's going up the hill. They look like fat little boys holding jubilee flags.

"'6'—an umbrella handle. Curve must be to the right because we want to hold the umbrella in the right hand.

"These illustrations are only suggestive. Every teacher will have certain devices of her own. See that every child learns the correct formation of the figures at this stage."

A teacher reported to me that, in endeavoring to grade a new pupil, he placed "6" on the blackboard and asked what it was. "A pig's tail."

The child must think of the number of objects rather than of the objects. An illustration given simply to amuse the pupils usually takes the symbol too far away from the idea which it is intended to represent.

Present the work to the child in the manner advised above to-day; to-morrow place "4" on the blackboard and note what it signifies to the child. Will he think of the number of fingers on his hand, or will he recall the darning-needle and the chair?

"Make a two roomed house; call the right-hand room the units, and the left-hand room the tens. The children have the bundle in the left hand and no slats in the right, so that they will easily see where to put the tens and units. They have one bundle in the left hand, so we place '1' in the left-hand room, no slats in the right and so we place 'o' in the right-hand room.

"'We will put our little bundles in the second room, called the tens room; all the single slats in the first room (units).'

More amusement—they will want a cottage roof to-morrow.

"Draw two houses adjoining one another, each having three rooms. Call attention to the neighbors: Mrs. Units, Mrs. Thousands (Mrs. Millions later on).

"They live next door to each other; each has three little children: Mrs. Units—(the baby) units,
(the tens) of units,
the hundreds of units.
Mrs. Thousands—(the baby) thousands,
(the tens) of thousands,
the hundreds of thousands.

"Refer to children's names, their Christian names and surnames."

Quite correct, but the outline would lead one to expect, "Keep the child simple."

Arithmetic contributes to the intellectual training and discipline and has a distinct practical value. A clear line of distinction should be drawn between thinking, clearness of reasoning with accuracy and reasonable rapidity on the one hand, and oral and written expression, with the simplicity, clearness, sequence, unity, and neatness in paragraph form on the other. Systematic drills, intensive rather than extensive, on the facts of addition, subtraction, multiplication, and division, aiming at accuracy with reasonable rapidity, should be given. Instead of focusing the attention on the result by asking for a certain answer the attention should be focused on the thinking and the conclusions, by simply stating the facts and leaving the pupil to do some independent work. Clearer thinking and greater power will result and we can then hope for clearer and more logical expression. Special care and attention are due the primary or foundation work.

PHYSICAL GEOGRAPHY IN THE HIGH SCHOOL.

By E. E. Ramsey,
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(Continued from January issue.)

Question 26. Give a list of them.

The list of experiments given lacked, because of lack of space, the element of sequence, but are nevertheless very suggestive. From the side of chemistry, the experiments group around the atmospheric gases mainly. The preparation and properties of oxygen (2), of carbon dioxide (16), of nitrogen (12), and of hydrogen (3), constitute this list. Another group of chemical experiments is given for rocks and the various forces and forms of weathering. These are tests for rocks and are used by six; chemical weathering and cavern formation, illustrated by the solution of limestones by acids—hydrochloric and carbonic are both suggested—are mentioned by the same number. Tests for hard and soft water are listed by two.

The physical experiments are more complete and are more largely upon the meteorological side. The weight and pressure of the air is given by nine lists and fourteen lists speak of the construction of a simple form of barometer and some demonstration of its use and action. Moisture of the atmosphere, relative humidity, the instrument for its determination and the hygrometer are the basis for experiments in nine schools. Fourteen schools use a series of experiments closely allied to the above group; these are evaporation as a cooling process (7), and dew point (7). Condensation is mentioned by two.

It is rather noticeable that mention of the thermometer, either its construction or its use, is omitted. Practically, the mercurial thermometer can hardly be constructed in the average laboratory, but it should receive definite attention at least. The "air" thermometer can be constructed and illustrates the essential principle of both action and use.

The important subject of heat and its effects aside from its study in thermometry is mentioned by 15 reports; four others give some experiments of conduction in gases, liquids and solids. Work of this kind which will illustrate the formation of convection currents in the air is within the grasp of high school students. The supposed cause of the geyser may be illustrated under heat phenomena (3). The Helior experiment (1), the delta table (1), the clinometer (1) and an experiment on stratification (1) are given.

Some work upon light, mainly based upon prismatic analysis, is offered in seven schools. A few schools other than those giving no chemical and physical experiments, do not report.

Question 27. How much work on meteorology do you do? The question is a repetition of a previous one and the results are the same. On the average somewhat more than six and one-half weeks are given to the subject.

Question 28. Does meteorology possess any advantages over the other phases of physical geography as a high school subject? If so, what?

The canvass of the opinions on the first part of the question are: seven do not answer; seventeen feel that there are no advantages in meteorology; while thirty-nine answer in the affirmative. Under the second part of the question, the largest number of votes is given to the practical character of meteorology (9). The ease of observation (7) and the interest that students manifest in the subject (7) come next. Another answer, "Knowledge of the weather is of great importance and can only be gotten in physical geography, while some of its other phases, such as plant and animal geography and the geography of man, can be acquired in biology," can be credited to the practical character. Closeness and consequent reality of the subject (4), always at hand, first hand study (1), facilities usually present (1), more self-evident to the average pupil (1), intimate way in which the weather affects one (1), thoroughly concrete (2), more tangible (1), are answers all of which have, among other ideas, the idea of actual contact so necessary with the thing studied in science and so easily reached in meteorology.

Another set of answers naturally group themselves around the laboratory phase of the subject. The actual experience of the students can be used (3); it is a better laboratory subject (2); observations are readily made (7); observations are very readily checked (1); it makes laboratory work necessary (2); and the apparatus required is more simple and interesting (2); the experiments needed are simple and interesting (1). Most of our knowledge comes as second-hand material. One teacher emphasizes the value of meteorology because of the directness of knowledge obtainable. The rapidity of change in weather conditions (1) makes it possible for the student to follow out in a relatively short time a fairly complete cycle of weather. In no other phase of geography and no phase of biology can this be done with equal facility.

The ease with which field work may be done in meteorology (7) is one of its most commendable features. The schoolyard, or even the windows of the schoolroom, is the field. Observations may be taken three times per day without taking time from other work. Every student can be doing some or all phases of the work. Data thus collected furnish an abundance of material for laboratory work, although all the work done should not be based on these observations for the reason that they are local in character. But the uniformity of plan in making observations renders the necessary use of data from other places not objectionable.

The bearing that this subject has on the humanistic side of geography, while not yet worked out to specific truths in all cases, is so well recognized that this argues in its behalf. Any study of animal and plant geography or of the geography of man recognizes the fundamental character of climate as an element of environment. It is upon climate that many of the forms treated of in physiography are dependent. The forces of weathering are mainly those which depend either directly or indirectly on climate; rivers and river action have the same dependence; lakes, and seas, owe their existence or their extinction partially to climatic changes; it is certain that the profound changes produced by the glacial age were preceded by marked changes in climate as one direct cause and that climate has determined the rate of development and the direction of development along all lines in the glaciated areas, subsequent to the close of this age; the ecological factors surrounding plant, animal, and man are very largely climatic in character. Of the forms generally given in geography courses, this leaves only the origin of mountains, the origin of vulcanism, and tides as the ones not intimately related to climate. Then, too, the study of the genesis of mountains and of vulcanic forces is of doubtful value and position in physiography. It seems clear that meteorology is in reality basal for physiography proper. So whether one considers the direct or the indirect effect of climate on man, the problem resolves itself into one of basic contact with man. One teacher evidently has this idea in mind in saying that a knowledge of meteorology reduces living to a more scientific basis.

Now in addition to the availability of laboratory data, the availability of charts, weather maps, articles on weather and its various phases, should all commend themselves to schools as added reasons for incorporating this study in the course.

THE LIST OF QUESTIONS TO COLLEGE, NORMAL SCHOOL AND UNIVERSITY TEACHERS OF PHYSICAL GEOGRAPHY IS GIVEN BELOW:

Question 1. Is physical geography adapted to high school work?

The answers from 21 papers are stated in the following ways: no, 1; yes, 17; decidedly so, 1; can be, 1; excellently, 1; pre-eminently so, 1. This makes a total of 18 who are unqualifiedly in favor of the subject. "If but one science can be studied this serves better than any other to give a kind of general introduction to nature, taking up such phenomena as will be met with most frequently in life and consequently bringing school work into closer relations with after life than any other single science. This implies, of course, that its subject matter shall be properly selected and wisely taught."

Question 2. Rank it with zoölogy, botany, physics, and chemistry in point of adaptability.

Six state that geography is just as good as any of the four sciences mentioned, three say that it is superior to any as a freshman science; three feel that it is the equal of the biological sciences and superior to the physical sciences; one has the opposite opinion; two think it better than the others; one does not know; two do not answer; one states that it is inferior for scientific training because of difficulty of field work; one puts it that its value depends largely on the teacher. This statement does not answer the question inasmuch as the ranking is based upon teacher and not subject, and subject matter. Only one marks the subject down badly. This is done largely because of the impossibility of doing adequate field work. He evaluates zoölogy at 100%, botany at 90%, physics and chemistry at 80%, and physiography at 20%.

Question 3. Where would you have it placed in the secondary course of study?

The elements of the subject should be taught in the grammar school; the subject may be early in the high school course if either commercial or rational geography follows (1). Geography can be given profitably in either year (1). One would like a divided course, the parts coming in the freshman and the senior years (1). Physics and chemistry should precede it (1); another prefers to have elementary physics precede or go hand in hand with it. One favors senior work and twelve state that the freshman year is the better place in their judgment—just as

in the high school answers the freshman year leads all other years singly or combined.

Question 4. Give your reasons for this selection.

The value that geography has as a generalized, introductory science is the strongest recommendation for having it placed in the freshman year (6). It is a sequel to and a fairly direct continuation of geography (4). Geography is a broad subject of general interest (3) and therefore should be studied early and by many (2). It bears a close relation to the phenomena habitually observed on every hand (3). Probably other sciences deal with as great a number of phenomena, but these are not so evident or so readily seen. Its range and ease commend it as the first science (1). It is adapted to boys and girls of beginning high school age (1). Because of the fact that so many quit high school early in the course (1) and because it is so adaptable (1) make it easily the best science to give in the first year's work. It opens the eyes of young students as a descriptive subject (1). Another favors a position in the freshman or sophomore year, because of the mathematical character of the physical sciences.

Two answers are quoted in full: (a) "The reason why physical geography should be put as early as possible lies in its nature as an appropriate introduction to the natural sciences and its close relations with phenomena habitually observed. The reason for putting in an advanced course consists first in the fact that geography study has been "dead at the top." Neither pupils nor teachers know that the subject leads to anything else or has any other place in the world outside the class room. The second reason is that good teachers of geography cannot be obtained so long as the subject occupies only a small fraction of their time. There should be enough geography work in the schools so that it would pay a young man to train himself for that work primarily. Physics and biology have realized this ideal in many high schools." The author of this statement favors the divided course as pointed out in the answers to question 3. (b) "Before the student specializes in science, he should acquire the proper perspective, that is, a general outlook over nature. He should be given an elementary conception of chemical, physical, and biological phenomena as they are illustrated in the interaction of the earth, water, and air and living things. This can be given only by geography."

This summarizes the statements of those favoring first year work. One report believes chemistry to be *the* basal science and the geography should therefore follow it as a junior or senior subject. The paper favoring the removal of the subject from the secondary curriculum states as the reason that it is a subject requiring a wide range of observation and maturity of mind. The difficulty that this teacher seems to be in is mainly the fact that a lifework in geography and geology gives him a mountain top view of the subject. ***Exactly the same argument can be used on every subject*** in the high school curriculum.

Question 5. Should the geocentric or the anthropocentric viewpoint be emphasized?

The largest number giving one answer (8) state that both phases should be coördinated. Six favor the emphasis on the anthropocentric, while five give the geocentric the preference. The human side should be incidental (1), anthropocentric geography should be emphasized in the latter part of the course (2). Another states that he does not know but that he considers the distribution of man very important. One teacher in a state university in the middle west makes this comment: "The geography courses stand too much for the so-called cultural development. Certainly it is time for such modification as will bring about a closer relation between physical geography, agriculture, botany, history, and industrial geography. There is a strong demand for physical geography of this kind, especially so in agricultural communities. This means, of course, that the physiography of the land should receive the principal emphasis. The atmosphere should come in as a strong second." A normal school teacher says: "Earth conditions should receive largest treatment, but their influence on plants, animals, and men should receive much more complete treatment than in our text-books. I would largely exclude from the text-books facts that do not have an anthropogeographic significance."

Question 6. What value does physical geography have as a high school subject?

After one has read the list of answers to this question the values of geography will be much more clearly defined than ever before. Some of the answers will be quoted: (a) "As a descriptive study, it opens the eyes of the pupils and exercises them. As an application of physics, chemistry, and biology, it trains to a logical adjustment of principles." (b) "If properly taught, it gives desirable information needed by men. It interests people

in the earth on which they live and leads to future acquisition. It trains observation some and the reasoning powers more. It broadens." Many of the papers use the first restricting clause, "if properly taught." But this is not peculiar to the subject itself, but manifestly to the teaching. Five others consider it a most valuable informational subject. The element of interest is brought out by four. Training the observational powers is emphatically given in six reports and the training of the reasoning powers in seven. These two should not be considered different and distinct mental acts, but the reasoning is the result compelled by observation in well-directed work. Other reports (6) state what is essentially the same thing in these words: "Geography induces reasoning from cause to effect." Two more general terms are given, but this cause-effect and effect-cause reasoning is one of the elements in them at least. "Disciplinary value" is given by four and the value is designated as educational by two others. The total number of reports touching upon these very closely related phases is 18. It broadens and liberalizes (2).

(c) "It affords a broad basis for thought upon phenomena that will surround the individual for life and thus tend to stimulate mental activity perhaps every day, and perhaps a hundred times a day; while subjects related to objects or phenomena that seldom enter into later daily life, unless it be a life of specializing, do not 'carry' so far. Problems of the earth, air, winds, rain, etc., are ever present. As a crude illustration: Better teach a savage far out in the Pacific how to make a better fish-hook than to teach him wireless telegraphy! The thought of the fish-hook is ever with him." The first idea is variously expressed in other papers. Four speak of it as the relation between physiography and environment of the race. The same number put it in this way: Geography familiarizes the student with phenomena of everyday life. The geography of relation is the working of another. Physical geography has more points of contact with life than any other science (1).

(d) "There are few studies more truly educational than is physical geography. No other science makes a stronger appeal to the observation and through the observation to the reason. In physical geography the intelligent teacher can more easily avoid the mere cramming and COMPEL reasoning than in any other science. Causes are rarely single and simple forces cooperate to produce results. Data are easily collected and conclusions are most readily forced upon the mind." (e) "Dealing

as it does with the pupil's immediate natural surroundings, it opens his eyes (and mind) to the great underlying truths of geological and physiographic science and causes the earth to take on a new aspect." (f) "Geography teaches pupils to observe their environment more *understandingly* than any other of the sciences. It furnishes more substantial data for reasoning from cause to effect and from effect to cause than any other science. It gives the best introduction to all science work." The last point is brought out in four other papers. "I know of no science so useful as physical geography in allowing correlation of cause and effect." (g) "Geography shows the pupil his relation to the earth. It is broadly cultural. The geographic viewpoint is more clearly elementary and naturally precedes formal science. It not only forms the proper introduction to science of the later years, but if the pupil goes no farther, it gives him the best possible training as an introduction to the real experiences of life." (h) "It is the best subject in the curriculum to teach pupils to think straight, to see straight, and talk straight."

Question 7. What proportion of time should be spent in field work, and in recitation work?

Nine reports favor the recitation taking up two thirds or more of the time. Four others favor one third to one half of the time for this work. On the question of laboratory work and field work there is a wide range of opinion—so wide that there are few combinations possible. For the laboratory work the answers vary from one sixth of the time up to a "large amount of the time." Three place the amount as large, while two others suggest one fourth to one third. One says that the laboratory work should take up the least time.

The field work, five say, should be small in amount. Two put the laboratory and field work together and would have it occupy one half of the time. It should be sufficient in amount to master local conditions (2). Field work depends on the teacher and the locality (5). Others answer from five half days to "most of it."

Question 8. What should be the character of the field work?

The general character of field work depends upon the character of the local field. What would be good field work for one field would not be good field work in another region. If such work has definite values, however, the methods in the work, the mental ends, and the informational ends to be sought can hardly vary so widely as the fields. The first consideration given is to have

the work adapted to the local field (5). The physiographic forms and phenomena as shown near the school (10) furnish the subject matter. This statement implies adaptation to local conditions, thus making 15 answers that emphasize this point. Written reports (2) or laboratory work (1) should supplement outdoor work. The suggestion that the students should be trained in drawing logical conclusions from their observations (3) is as vital as setting the keystone in an arch. Habituating the student to seeing common things (2) is another characteristic. The human response to environment as seen in local industries, railroads, etc., make a fruitful phase of field work (2). One report has a very suggestive negative included: "Field work is not haphazard journeying." Another says that it should not include topics the teacher does not understand.

Question 9. What should be the character of the laboratory work?

The study of maps (6) and models (4) leads the list of suggestions. Sand table work (2); rocks, minerals, and soils (3); weather and climate (2); the use of weather instruments (1); notebooks (3); and demonstration work in related sciences, which will throw light on physical geography (2), constitute the next most frequent suggestions. The physiography of the locality first and the physiography of the United States next should form the basis for laboratory work (1). Laboratory work should be of such a character that it will supplement defects of the local field (1). From the mental standpoint, these suggestions are made: Laboratory work should furnish concrete mental material; it should be inductive in character; much time should be given to thoughtful interpretation (1). A phase of this work that needs more definite attention paid it is the human response to and human dependence upon topography, physiographic forces, and weather and climate. One answer is partially thrown in a negative way: "It should not be optics, physics, or chemistry. "Anything which illustrates (1) new principles or (2) enforces or emphasizes those principles the pupil is familiar with" constitute the general basis for laboratory work (1).

Question 10. What is a fair apportionment of time among the various topics in physical geography?

Question 11. How extensively may one go into the study of meteorology?

The ocean as a separate topic should receive about one month; water, including oceans, lakes, and rivers, is given one third of

the time; the earth as a planet receives about one month; the land is given four months; man and life conditions averages about one month; two suggest, however, that this should not be a separate topic, but should be given whenever a point of contact occurs. Meteorology is given nearly three months' time. The total time allotted does not aggregate nine months, because not all of the topics were covered in all reports. These questions have been put in this form, not for the purpose of having fixed standards of time set for each, but for the purpose of securing an evaluation of the various general topics in the subject.

Question 12. To what extent should models and intricate apparatus be used in demonstration work?

As to models, seven state that they favor a wide use of good ones, while the same number would make but little use of them. Maps are frequently mentioned and lantern slides once. There is unanimous objection to intricate apparatus, but all favor the use of simple forms. It is pointed out that the intricate forms appeal to the student for the sake of the apparatus alone and not for the sake of the results. Models are too expensive to reach any wide use in the average school.

Question 13. Should chemical and physical experiments be given as demonstration work for their physiographic bearing?

One paper states emphatically NO. Four think that such work is not valuable in general. The same number favor a limited use, except in meteorological work, where they may be used most advantageously. One favors a large use of such work. "If clear and helpful experiments" can be devised, six favor their use. Four others insist that the experiments must have a definite *physiographic bearing*. An extreme and very questionable position is taken by one teacher who says that when a student does not know the effect of heat, for instance, upon any material with respect to the volume of that material, tell him the facts in the case.

General Conclusions.

(1) Geography is a basal science; it deals with the larger aspects of the earth and of the physical control of the life of the earth, including plants, lower animals, and man. The other sciences are more specific; they deal with the minutiæ of special phases of geography. The *view* that the subject presents is thus one that makes it basal. The method to be employed, in accordance with the subject matter, must be of a broader and less specialized character than that in the other sciences recognized

in secondary work. Both of these facts commend the subject as one particularly fitted to the stage of advancement of the freshman year. From the absence of laboratory work of any kind in the grammar grades to the delicate (comparatively so, at least) laboratory work in the biological sciences, is a long step. The geography furnishes an easy and natural transition to the biological sciences and in a measure to the physical sciences. The failure of the grammar school to give its students any of the fundamental facts of the old-fashioned natural philosophy and the presence of nature study in its present rather prevalent hopscotch character render a preliminary science very necessary.

(2) Geography must be made a laboratory and field science in whatever grade it is taught. Five recitations per week upon a text *cannot* constitute geography. Here as in other sciences the imperative demand of the subject matter for laboratory practice is one of its most commendable qualities. The schedule should allot it 8 or 10 periods per week and thus place it on a par with the other secondary school sciences. Some time should be given to the instructor for class work in the field, the amount to be determined by the availability of material.

(3) Geography should be taught either by an instructor of broad science training, or, better still, by one who has specific training in the subject. The former condition is invaluable, but such an instructor may lack the field-sense so essential in geography work. Such subjects as Latin and mathematics have reached a relatively high level of efficiency, partially because *trained* teachers are demanded in them. Many schools have habitually turned geography over to *any* teacher whose schedule is not entirely filled. A canvass of the answers to question 4 of the high school questionnaire makes the situation more hopeful, however. Of 59 answering the question, seventeen have done one year's work; four have done two and one half years'; one has done five years' work. This leaves four who have probably taken a degree in geography or geology. Ten have done less than a year's work, while eleven have done none. The point of preparation is emphasized by some of the professors answering the university lists as being the chief difficulty with the subject. One prominent university authority upon physiography and geology adds to his answers the following pointed letter, which bears upon the point under consideration. "The difficulty, as I see it, is simply this: Many of the teachers of physiography are not prepared to do their work. When as much preparation

is required of teachers of physiography as is required of teachers of Latin, we shall have as good results from the study of physiography as from the study of Latin—better, if the subject is better adapted to high school uses."

(4) Some time, probably as much as one third of the time, should be devoted to meteorology. So much physiography, topography, industry, and even history is conditioned by weather that its treatment is fundamental. It has already been pointed out that this line of work possesses some points of advantage over other phases of geography. The ease with which it lends itself to field work; and to laboratory work; the rapidity of change enables one in a short time to demonstrate an entire cycle of weather; the natural interest of people in the weather; its very practical character; and finally the fact that it underlies so much physiography proper seems to warrant such a recommendation.

(5) An examination of some of the manuals for general science and of some of the courses in that line leads to this recommendation: Geography may take, in considerable measure, the place of elementary science and retain its integrity as a science. At the same time the ends of the general science are met in a peculiarly favorable way in that there is a framework around which the principles may be clustered. One prominent university teacher of meteorology says: "Meteorology is splendidly adapted for school study. Wherever the subject has been properly taught, it has interested the student." Professor Mark W. Jefferson in the State Normal College of Ypsilanti, Mich., writes as follows:[1] "The difficulty under present conditions of making it (physiography) anything else (than a text subject) gives me an inclining toward meteorology. In my own state I know by investigation that the practical difficulties in the way of field excursions mostly result in preventing them. * * * Real observational work with the weather has no such difficulties.

(6) Geography is in a state of transition. It is not many years since there came a demand for the recognition of the ecological factors of plant and animal (lower animal) life in botany and zoölogy. Exactly this transition is coming in geography. The human ecology—if it may be so called—in geography must be brought out more definitely, thus making the subject one of practical import to a student.

[1]School Science and Mathematics; Jan. 1909.

NEEDED ADJUSTMENTS BETWEEN SECONDARY SCHOOLS AND COLLEGES.[1]

By Otis W. Caldwell,
University of Chicago.

Two years ago fifteen members of the University of Chicago faculty were asked to serve as a curriculum committee to make a careful investigation of the courses of study in the different colleges of the university. This committee was composed of members from the instructional and administrative staffs of the colleges of arts, literature, science, philosophy, commerce, and education, and its work related more or less to each of these colleges. There were several reasons for the appointment of this committee. One of these was found in the lack of close articulation between the work of the first years of college and that of the schools from which the students come. The public high schools are meeting the needs of the communities they serve by introducing courses of instruction and a significance of content and vitality of method which together have for some time presented to the colleges a new and highly important situation. When the public high school was being established the colleges rendered much assistance by outlining the courses for it. But now it is an autonomous institution, and its competent faculty is studying its problems to the end that it may serve its community in the most efficient, democratic way. This, in its influence upon the high school students who desire to enter college, sometimes forces them to take a high school course quite different from that of their fellows; sometimes, in case of students who late in their high school course decide that they wish to go to college, it prevents them from so doing and sometimes causes the student upon entering college to be conditioned by several units of work. Of the 450 freshmen entering the University of Chicago on October 1, 1910, 150 were conditioned, and in many other institutions the showing is no better. One large university is said to have conditioned a much larger percentage of its entering class last autumn—the amount of conditions varying from one to seven units. These conditions, in themselves a direct confession of weakness of the college plan, presented one phase of the problem. Another aspect was presented in the difficulty of arranging first year college courses to fit the educational needs of students who enter with varying amounts of entrance units.

[1]Preprinted and rearranged from Proceedings of the National Education Association, San Francisco, Cal., July, 1911.

Still another problem of the committee was found in the difficulty in securing from the curriculum of the different colleges of the university a sufficiently large number of coherent and progressive courses: (1) to give purposeful college students a wide range of choice of careers for which they may prepare while in college; and (2) to enable the administrative officers to stimulate students of less purpose—of the drifting class—to select coherent sequences of courses that may give them definite and more intensive preparation for effective work when out of college.

At the outset it became evident that extensive changes were advisable, both with reference to our relations to high schools and in the organization of the curricula in the colleges. As a result of almost two years' study of the situation, with the assistance and coöperation of those who are directly interested in high school work, a new plan was drawn up. This was passed almost unanimously by the general faculty early in June of this year.

The plan provides one specific requirement of three units (three years) in English. This English is expected to give reasonable facility, accuracy, appreciation, and readiness in use of the mother tongue, and the university will look for these attainments rather than to the particular content and method of the English course, which latter points the high school is expected to determine in the light of its own immediate study of work. Other than these three units of English, no specific subject requirement is made and there are members of the committee above referred to who believe, that English has not proven that a special requirement should be made of it. Requirements based upon recognized educational principles are made in the following way:

Those subjects that have long been recognized in high schools are arranged in six groups, as follows:

1. English.

2. Ancient languages (Latin and Greek).

3. Modern languages other than English; German, French, Spanish.

4. Ancient history, mediæval and modern history, English history, United States history, civic economics.

5. Mathematics.

6. Sciences, physics, chemistry, botany, zoölogy, general biology, physiology, physiography, general astronomy.

English, as stated above, is represented by a requirement of three units. From some one of the five remaining groups the student is expected to take a principal sequence of at least three units, and from another, a secondary sequence of at least two units, and in all from the six groups he is expected to present at least ten units.

If Greek, Latin, or one of the modern languages is chosen for either primary or secondary sequence, the three or two units, as the case may be, must be in a single language. Also not less than one unit of physics or chemistry may be offered, and not less than half a unit of any other subject.

When presented not as a primary or secondary sequence of units, not less than one unit will be accepted in Greek, Latin, any modern language, mathematics, physics, or chemistry; and Latin may not be continued in college unless at least two units are presented.

In addition to the ten units thus provided for above, five additional units are required. These may be offered in any subject for which the high school gives credit toward its own diploma. This means that these five units may consist of any high school vocational subjects, as agriculture, domestic science, commercial arithmetic, bookkeeping, stenography, manual training, etc.; or they may be presented in addition to the ten units from the groups given above. The whole plan therefore provides specifically for three units in English; for a principal sequence of three units and a secondary sequence of two units to be chosen from five great groups of subjects; for two additional units also from the five groups; five units from any subject offered by the high school; not less than one half a unit in any subject; entrance with conditions will not be permitted.

It is thus possible that a student may come to college with work in but three of these six branches of knowledge. It is also possible for him to come to college having work in all of them. In any event, another part of the plan adopted insures that during his first two years in college and his high school together he shall have attained acquaintance with the fundamental aspects of each field of knowledge. Thus the two principles of intensification and distribution are cared for.

Obviously this plan is an attempt to place college entrance upon an educational basis instead of a basis of dictation and of keeping accounts. It asks for a good quantity and quality

of training in the use of the nation's language. It asks for sequential work in enough lines of study to lay a foundation in scholarship, and leaves entirely to pupils, high school teachers, and community to decide what those lines of study shall be. It recognizes vocational studies as having educational and cultural value quite worthy of place in the preparation of students for college work. Indeed, we recognize these as subjects needed quite as much in order that students who go to college may not lose their social and industrial perspective as that those who do not go to college may utilize these subjects in practical affairs.

This plan is intended to leave the secondary schools free to experiment and find the methods and subjects best adapted to develop socially efficient and scholarly students. It is hoped that the plan may open the way for a genuine coöperation in the study of the many unsolved problems of democratic education, and may encourage both schools and colleges to careful experiments in the subjects, methods, and results of our teaching. Effective democratic education for all the pupils in the high school is needed by the community; and is at the same time better for future college work than any narrowly prescribed academic training.

High schools that are in coöperation with the University of Chicago and which meet these broad requirements will be asked to maintain a quality of work that produces efficient students, and inspection will be upon that basis. Upon recommendation of the faculty of the coöperating high school its graduates are admitted to the university without examination, and the school will be tested by the ability of its graduates to do good work, as indeed are those of its graduates who go from high school into positions of employment. If a considerable percentage of its pupils fail to carry their work the school will be taken from the list of coöperating schools, until upon further inspection its product seems likely to succeed. A carefully prepared record of all students will be sent regularly to their respective high schools, thus enabling both high schools and college to test their efficiency, not by a single examination or by a single student, but by a continued investigation of the ability of students to do efficient work.

For several years a rigid method of grading students has been in force in the colleges of the university. By use of this method inefficient students are eliminated early in the course; the less

efficient the earlier they are eliminated. Over one hundred students have thus been dropped in each of the past two years.

As a means of further coöperation, and to secure the most effective teaching in the beginning of college courses, we have invited a large committee of high school men to visit those courses in the university which students take during their first years in college. We shall expect pointed and valuable suggestions from these "college inspectors," and I suspect must be prepared to defend ourselves or eliminate some questionable practices in college teaching.

The general plan adopted by the faculty also includes regulations through which we hope better to meet the needs of college students all through their college course. These bear a definite relation to college entrance. An outline of this plan will show its significance. In the first year of college work the student must continue the subject of his primary or secondary sequence offered for admission, with the exception that in special cases students may continue a last year full unit subject. This last provision is made possible since high school students often "find themselves" in some subject of their last year's work. Also during the first two years, preferably the first year, the student must take three majors of English, one major of public speaking being included therein. Also in two years the student must, together with the high school work presented, have as much as four majors in each of the groups 2 to 5, listed above. This insures acquaintance with the great divisions of human knowledge, and if high school work has been arranged as herein outlined, this plan still leaves the student large election in college. Furthermore, during the last two years of college work the student, with what he has done in the first two years, must complete nine majors in one department and six majors in another. He may not take more than fifteen majors in one department. Thus we plan to secure intensification within departments in which the student wishes especial preparation, and also secure distribution which gives general cultural acquaintance.

ADAPTATION OF PHYSICS TO DIFFERENT TYPES OF PUPILS.

By S. E. Coleman,
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Need of Adaptation.

One of the chief obstacles to the best success in the teaching of physics is the heterogeneous character of the class. The fund of experience, the interests, and aptitudes, and the present and future needs of the pupil are factors which should largely determine the matter and method of the course; and these factors, as they apply to the different individuals of a typical physics class, are irreconcilably different. To compromise differences on the basis of the "average" pupil is lamentably unsatisfactory; for the average pupil, so far from being in the majority, is—like averages in general—a mathematical fiction.

Two Types of Pupils.

From the standpoint of physics as a means of education, pupils are of two principal types. With those of one type the mental habit is analytical, logical. Before they reach high school age they have developed a keen interest in the how and the why of things. They have learned to think in terms of cause and effect. Even in childhood their interest in what a mechanical toy does is quickly subordinated to the desire to find out how it works—with consequences perhaps disastrous to the toy but more or less satisfying to the inquiring mind. Thus from the earliest years through life this quality of mind manifests itself; it is native, fundamental. Pupils of this type take to mathematical work with comparative ease. They throw the burden where it belongs, not on the memory but on the understanding. They come to physics admirably fitted for the work, with a stock of miscellaneous information and experience which is extensive and very much to the point, and with interests and aptitudes keyed to the demands of the subject.

Pupils of the other type are characterized negatively by the absence or weakness of the mental attributes mentioned. On the basis of this negative characterization alone, the type includes the mentally inept or unfit. These do poorly in physics; but they are consistently poor in everything else as well. But defect of analytical and logical power is very often compensated by strength

in other directions, as shown by excellence in the languages, literature, history, art, and music. One element of strength with such minds is a retentive memory, which, on occasion, is made a substitute for reason. The inadequacy of the substitution is most evident in the mathematics and in physics, where in extreme cases it breaks down completely.

The above classification does not divide the sexes, but it does unmistakably show a sex difference. Among high school pupils a very large majority of the first type are boys. The second type includes most of the girls, together with a considerable percentage of the boys. Whether the difference of type, in so far as it is attributable to sex, is native or acquired or partly both is not germane to the present question. It is simply a fact to be reckoned with in education.

The Educational Problem.

How best to adjust the instruction in physics to the special needs of these two classes of pupils is the problem demanding solution. It is not solved by giving a course adapted only to the more capable boys, leaving it optional with other pupils to take the work and get what they can out of it or to decline it, as they may choose. Neither is it satisfactory to adapt the work to the less capable, thus depriving the strong of that which is for them most worth while.

In the small high school, where there is only one class in physics, the best that can be done is to supplement the class instruction with more or less of individual help, the twofold purpose of the individual work being to help the weak over the minimum requirements of the course, and to provide extra work for the strong according to their ability. With a very small class, conditions approximate to the ideal in this respect, for the instruction can be very largely individual.

In large high schools the problem admits of various solutions. It is solved as an incidental feature of larger educational issues where several high schools of different types are maintained in the same city. The physics course of the manual training or the technical high school will naturally differ from that of the Latin school or a school for girls. It is not the purpose of the writer to discuss the large possibilities afforded by such exceptional conditions, but rather the adaptations which may be made to advantage in the undifferentiated high school of the large majority of our American cities.

Adaptation in such schools usually takes the form of a general year course, open to all students, followed by a more advanced half year or year course, intended primarily for those who are preparing to enter college or technical school. This plan has obvious advantages, but at best is only a partially successful compromise. If the work of the first year is reduced in amount and adapted in character to the less capable members of the class, it is not of the sort that should be given to the others. For them the work is an occasion for half effort and a discipline in the art of loafing. The advanced course is a confession of maladjustment, being in the nature of a supplement to incomplete work. If given only for a half year, it necessarily consists of disconnected fragments, which are only imperfectly articulated with the work of the introductory course.

Segregation of Pupils.

The adequate adjustment provides for the segregation of the pupils from the beginning of the subject. There is much to be said in favor of separate courses in physics for boys and girls. This is not a segregation according to ability in the subject or according to mental type, but rather in conformity with the normal daily experience, interests, and future needs of the sexes. But the educational values of the subject are not so largely influenced by sex as to fully justify segregation on this basis alone. Mental type, as above outlined, should largely determine the scope and character of the work attempted and the methods of instruction. It is a waste of time to emphasize the mathematical side of physics with pupils who have neither mathematical inclination nor ability, whether they are boys or girls; but such work is of great value to boys who have mathematical ability. And further, there are boys as well as girls whose daily life has awakened but little curiosity concerning physical matters in general, and whose physical concepts are vague and chaotic. These need the same sort of help, regardless of sex; and the boys would not get this help in a class with capable fellows.

The Oakland Plan.

Giving due weight to all elements of the problem, the best solution apparently is to offer two parallel courses in physics, differing largely in method and in the amount and character of the subject-matter, but open to both sexes. This plan has been followed for some years in the Oakland High School, and it

works well. The two courses are designated respectively as full and brief physics. The full course is intended primarily for the more capable boys, and is taken by all who need physics for their work in college or technical school. With a selected class of pupils, the work is more vigorous and thorough than is ordinarily possible. The mathematical side of the work is emphasized, and includes incidental instruction, as occasion demands, in the sensible use of mathematics as a tool. Much attention is given to the practical applications of physics in daily life. The brief course dwells at greater length on the qualitative aspects of phenomena, omits much of the usual mathematics of the subject, reduces and simplifies the work in mechanics, takes fewer quantitative laboratory experiments, devotes less time to practical applications. Astronomical topics are introduced here and there, as they fit into the regular order of the work. Thus in dynamics, the motion of the earth and planets round the sun and of the moon round the earth, the bulging of the earth in equatorial regions due to rotation, the apparent diurnal motion of the starry heavens explained as the result of the earth's rotation, and the apparent seasonal motion as the result of the earth's revolution round the sun (based on observation of the brightest stars and some of the principal constellations), nature of the sun and stars as distinguished from the planets, relation of the solar system to the stellar universe. In heat, the inclination of the earth's axis, varying length of day and night, cause of the seasons, source of the sun's heat, solar energy as the cause of terrestrial phenomena (winds, rain, plant growth, etc.), physical conditions on the moon and Mars. In light, eclipses of the sun and moon, phases of the moon, the solar spectrum and its teachings.

The full course presupposes ability, aptitude, and adequate preparation for the subject. A good record in mathematics is regarded as evidence of fitness for the work. Although chemistry is not made a prerequisite, it rarely happens that any member of the class has not taken the subject. The full course thus fits in with a high school education which is somewhat specialized along mathematical and scientific lines.

The aim of the brief course is the general educational aim. It presupposes no specialization and looks forward to none. It purports to deal with matters of general interest and importance, and welcomes students whose intelligence and general training are such as may reasonably be expected of all third and fourth

year students in the high school. The only specific requirement is a certain minimum of algebra and geometry. As regards the content of the course, it is certain that all girls and many boys are more interested in learning something of the orderly plan and meaning of the universe at large than they are in learning details about hydraulic presses, steam pumps, steam engines, dynamos, etc. The brief studies in astronomy above outlined never fail to arouse the deepest interest, which reacts to the benefit of the more prosaic side of the work. It should not be overlooked that this astronomy is also applied physics, serving admirably to illustrate the laws and principles of the subject, and that, as information tending to broaden the mind and to enlarge one's outlook upon life, it is worth more than much of the practical physics that we are at present so intent upon bringing into the high school course.

Time and Credit.

The two courses are given the same amount of time on the school program, and each is completed in one year; but the full course demands more time on the outside, and ranks as a course and a half toward graduation. The work would be extended over a year and a half if circumstances permitted.[1]

Pupils in the Brief Course.

The choice of the girls is the brief course, almost without exception. It is preferred even by those who are fully competent to take the other, because the subject-matter and the less intensive treatment are more to their liking. It is taken by a considerable number of the boys for the same reason, and not infrequently for the further reason that they have neither the training nor the ability demanded by the full course.

A Suggestion.

It is not essential to the plan and purpose of the brief course that it should include the astronomy outlined above, or any part of it. Although very much worth while, there is an abundance of good material that may take its place. Elementary meteorology is simple applied physics, is of general interest, and serves admirably to illustrate many topics in mechanics

[1]Since this article was offered for publication, our school program has been arranged to give 7 periods per week during the first half year and 8 periods per week during the second half year to the full course. The time allotted to the brief course remains, as before, 5 periods per week through one year.

and heat. This material will be found fully worked out in any elementary text-book of physical geography. Of like utility are such topics as the heating and ventilation of buildings, the fireless cooker, the use and dangers of volatile, inflammable liquids (gasoline, kerosene, alcohol), including tests of flashing point and burning point, artificial illumination, electricity in the home, etc.

A Rational Solution of Disputed Questions.

The differentiation of elementary physics into two parallel courses affords the only rational solution of certain questions on which there has long been an irreconcilable difference of opinion among physics teachers. Should the quantitative side of physics be brought out strongly, with quantitative experiments, derivation of formulas, solution of numerical problems, etc.? Yes, in the full course; in the brief, no.

If any class of students can derive reasonable benefit from the present mathematical courses of the high school, then the same class of students can derive equal or greater benefit from the mathematical work of the physics course. If it is profitable to study pure mathematics, it is no less profitable to put a modicum of the knowledge gained to the test of practical use; and physics offers almost the only opportunity in the high school for such use. The objection that mathematical physics is too hard is met by the answer that it is not so hard as much of the pure mathematics that the student has already taken—or endured. The objection that it is uninteresting is met by the same answer, with the advantage again in favor of physics, for the problems of physics have a more significant content. It should be admitted, however, that the argument is valid against both the mathematical physics and the traditional courses in algebra and geometry, *for a large percentage of high school pupils.* The physics teacher, when charged with inhumanity, should not attempt to justify himself by replying, *Tu quoque.* He should give the mathematical work in good measure to those who can profit by it, with full assurance that it is worth while, and should reduce it to a harmless and, let us hope, profitable minimum for the others.

The question as to the proper treatment of kinetics (the behavior of matter undergoing acceleration) finds a similar answer. With a selected class of boys, it should be possible and profitable to treat the subject quantitatively, in terms of both the gravitational and the absolute units of force; but with girls

generally and with many boys there is little profit in elaborating the quantitative relations. The choice of suitable illustrative material (practical applications, etc.) also becomes a comparatively simple matter, as already noted.

DISCRIMINATING USE OF THE TEXT-BOOK.

In the light of the foregoing discussion, it is clear that the use of the text-book calls for discrimination on the part of the teacher. It is the teacher's privilege to select and reject according to his own best judgment. If the contents of the text are well ordered, so that essentials can be taken and non-essentials omitted without break in the general plan and continuity of the subject, then an overplus of material becomes a valuable feature of the book; for it affords opportunity for choice, and its presence invites attention and stimulates interest.

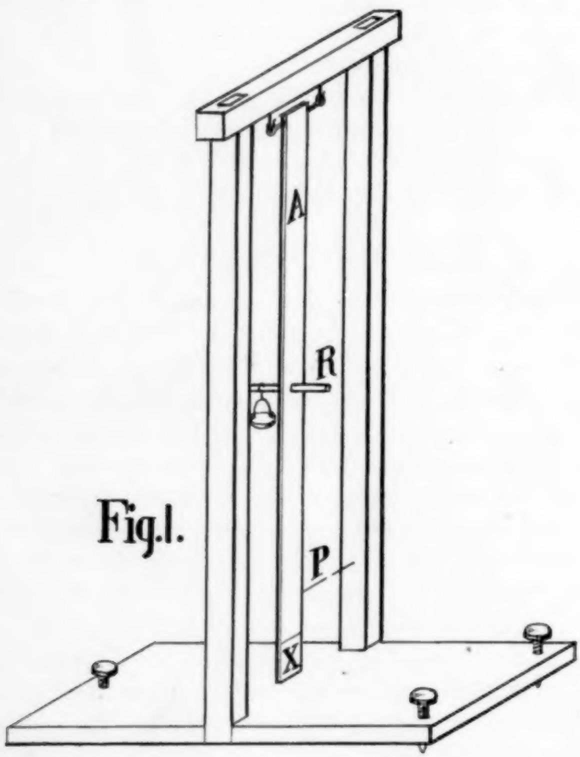
A MOMENTUM BALANCE.

In "School Science and Mathematics" for April, 1907, under section 9 of an article entitled "The New Movement Among Physics Teachers," in which a consensus of opinions and suggestions from 164 schools is offered upon the Teaching of Physics in Secondary Schools, appears the following: "As few units as possible should be employed, and they should be introduced only when a necessity for their use appears; i.e., they should be justified in advance as in the case of definitions and laws. By this thesis the more abstract units like the dyne and the erg would no longer be required in the elementary work."

The writer agrees with the spirit of the first part of the section but thinks that the dyne should be one of the "few units" which should properly go to make up a course in elementary Physics. The idea expressed in the dyne is one of the fundamental principles of many phases of mechanics and its clear comprehension opens a way into so many interesting fields of inquiry that it is worth the time necessary to study carefully. Most college students in their first year of work in physics have to wrestle seriously at first with the question as to whether or not *g* should be inserted in certain calculations. This appears to show that the recommendation of the above thesis is carried out in practice if not in principle in our western secondary schools. This, in the opinion of the writer, is an unfortunate condition of affairs.

To meet the difficulty which really seems to lie in the so-called abstract unit, the dyne, the writer has devised a simple apparatus for illustrating the unit force and roughly determining the value of the dyne. This apparatus consists of a broad, heavy base, with two stiff upright posts about a meter in length and rigidly connected at the top by a head-piece, as in the figure. Suspended from the head-piece by a pair of screw hooks and screw eyes is a thin inch-wide strip

Fig. I.



of wood, A, reaching nearly to the base and swinging freely as a pendulum between the uprights. A rod, R, several inches long is thrust through the piece A near its center. The front half of the lower three inches of the piece A is cut away, leaving the front surface of this section a portion of the axial plane passing through the supporting plane of the screw eyes at the upper end. If now this plane, as the pendulum hangs undisturbed, is not exactly under the supports of A, which may be determined by means of a plumb-rod suspended from one of the screw eyes, it may be brought to

this position by means of leveling screws in the base. A thin pointer, P, is arranged in apposition to another pointer on one of the posts when the piece A is hanging undisturbed. A cross, X, is plainly marked in the center of the surface at the lower end of A, and the apparatus is ready for use.

If a stream of water issuing from a small tube connected to a water supply is projected horizontally upon A at the mark X by holding the tube close to the plane, the pressure of the water will push A backward from its vertical position. A weight-pan is now suspended from the rod R at a distance of several inches from the central line of A so that its moment may oppose the moment of the force exerted by the stream of water. Weights are added to the pan, or the water is regulated at the tap, or both are adjusted until the indicating pointers are again in apposition. Then the moments are equal, and weight of pan times its lever arm is equal to the force of the water times its lever arm, whence the force of the water may be calculated.

Certain precautions are necessary in order to do good work with this apparatus. The bottom of the piece A has been prepared so that the water running down and dripping from the bottom end will be as nearly as possible in the line of gravity with respect to the screw eyes so that the adhesion of the water may tend as little as possible to displace the pendulum A. The stream of water must be adjusted so that it does not rebound from point X, but merely shoots off tangentially or drips off at the bottom. A little practice and patient manipulation will enable one to secure the correct conditions to a fair working nicety. If the water pressure in the main is not uniform, it may be necessary to use water from an over-flow vessel, which will steady the pressure sufficiently well for consistent results. While the water is flowing steadily, exactly as during the experiment, A is removed, the water is collected for a measured number of seconds and weighed. By measuring the diameter of the stream with a cathetometer, or by measuring the bore of the tube, the velocity of the flowing water may be obtained. When the water impinges upon A its velocity is reduced to zero, or practically so. By means of the data gathered it is now easy to calculate the force which acting for one second is required to change the velocity of one gram of water one centimeter. This is a definite force doing a specific thing. It is easily understood.

Let this value be called the dyne, and the student has the conception of the unit force in its simplest form. It is in no sense an abstract thing, but is as real and concrete as the foot or the pound. These things are the tools of the physicist and they must be made as real and concrete to him as are the hammer and saw to the carpenter. In this experiment, or some similar one, the student should make his first studied acquaintance with the problem of accelerative motion. The results, if obtained in the c. g. s. system, should be reduced to the common values of the foot and the pound. When the student discovers that it requires a force of about half an ounce to change the speed of a pound of water one foot per second, the subject can no longer be very abstract or abstruse to him. Taken from this point of view, the student will not be everlastingly insisting that a dyne is "that force which will move a gram mass one centimeter in a second," for the idea of distance does not appear in the above null method of measuring the dyne. The fact that gravity accelerates a mass about 980 times as much as does the dyne fixes the value of g and the method of obtaining the dyne shows that it enters all problems in which the velocity of bodies is changing.

LEADS WORLD IN ASBESTOS MANUFACTURE.

In 1910 the United States excelled all other countries of the world in the conversion of raw asbestos into manufactured products, but a very small percentage—less than 1 per cent of the asbestos used—was mined in this country, by far the larger part being imported from Canada. The total production in the United States for 1910, according to the Geological Survey, was valued at $68,357; the imports of raw material from Canada were valued at more than fifteen times that amount.

GRAPHITE MADE FROM COAL.

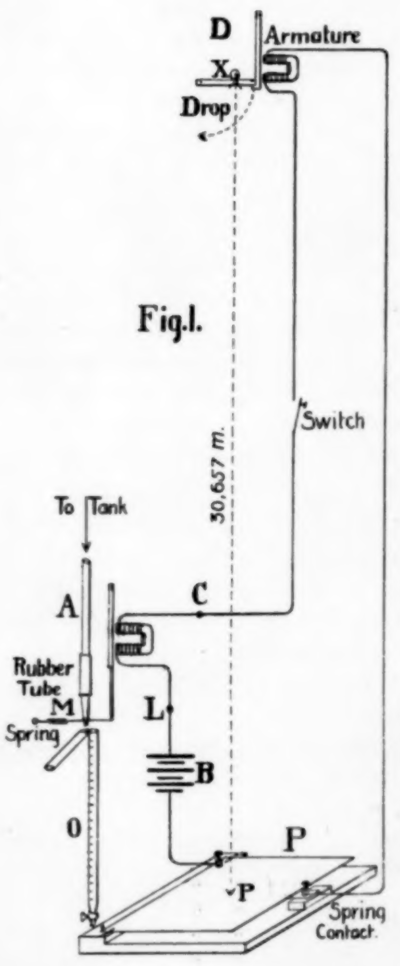
Graphite, the commonest use of which is seen in the "lead" pencil, is almost pure carbon. This mineral is therefore only a step removed from coal and in fact some of the natural graphite deposits are found in coal beds where the intrusion of masses of intensely heated liquefied igneous rock has metamorphosed the coal, thus forming graphite. An example of this natural manufacture of graphite out of coal is described in one of the reports of the United States Geological Survey on the Raton coal field of New Mexico. On the other hand, large quantities of high-grade graphite are artificially manufactured direct from ordinary coal.

In making lead pencils the graphite is mixed with a clay of fine grain and the greater the proportion of the clay constituent the harder the pencil. Exceedingly soft pencils with large leads contain but little clay.

THE EFFECT OF AIR RESISTANCE ON FALLING BODIES.

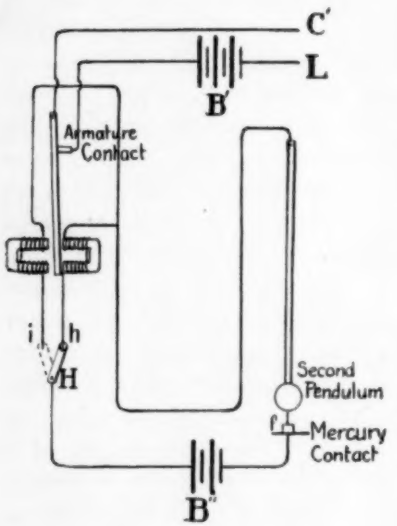
By Carl Kibler and Lewis Linder,
State Normal School, Charleston, Ill.

Galileo was the first to discover experimentally that there is a difference in the rate of fall of bodies of the same shape and material but of different masses. This he rightly ascribed to the air resistance. The writers of this paper determined to investigate this variation. It is evident a priori that since the masses and surfaces of spherical bodies vary respectively as the cubes and square of their diameters that the larger bodies should fall the faster.



No chronograph being available for direct time measurement the writers resorted to the indirect method of calculating the time of fall of a body by measuring the amount of water under a constant pressure which would flow through a tube during the time of fall. Then by means of a timing device the flow per second through the tube was determined. Using this last amount of water as a divisor into the amount which fell during the fall of the body gave the time of fall in seconds. The releasing device D, Fig. 1 was placed on the top of the school tower, giving the ball a fall of 30.657 meters. The circuit breaking device, P, was placed at the foot of the tower, directly under D. M is the measuring device of which A is the tube through which water, under constant pressure, flows continuously. It can be readily seen by in-

spection of Fig. 1 that upon closing switch Sw., ball X will be released simultaneously with the delivery of water from tube A into burette O. This flow is continuous until ball X reaches *p* of P, breaking the circuit of B, at the spring contact of P, when the water again flows into the waste pipe. The burette thus contains the amount of water which flowed through the tube during the fall of the ball.



The flow per second through A was found by means of the apparatus shown in Fig. 2. In this operation C′ and L′ were connected, respectively to C and L of M, Fig. 1, and switch H, placed, as shown, on pole *h*, thus closing circuit B″ through coil 2. When a contact is made at f, as the second pendulum swings through mercury contact *f*, the electro magnet 2 closes circuit B′ through the coil of M. While the circuit B′ is closed through M water will flow into the burette. After a period of nine seconds switch H was placed on pole I, closing circuit B″ through coil I, and breaking the circuit B′ at the close of the tenth second. It can be seen that when the circuit B′ is broken the burette contains the water which has flowed through the tube A in ten seconds. The average amount of water caught in this manner during a number of trials divided by ten gives the flow per second. This was found to be 8.23 cu. centimeters. The amount of flow during the period of fall of ball X divided by 8.23 cu. cm. gives the time of fall in seconds.

The following results were obtained with lead and steel balls of the masses and diameters given below:

Lead Balls.

Trial	Dia. of Ball	Mass of Ball	Amt. of Flow	Time of Fall
1	4.40 mm.	5.25 grams.	22.2 cu. cm.	
2			22.1 " "	
3			21.9 " "	
4			22.0 " "	
5			22.0 " "	

Trial			Amt. of Flow	
6			22.0 " "	
7			22.0 " "	
8			21.9 " "	
9			22.0 " "	
10			21.9 " "	
Average			22.0 " "	2.67 seconds

Trial	Dia. of Ball	Mass of Ball	Amt. of Flow	Time of Fall
1	3.27 mm.	2.30 grams	22.3 cu. cm.	
2			22.2 " "	
3			22.2 " "	
4			22.2 " "	
5			22.2 " "	
6			22.2 " "	
7			22.1 " "	
8			22.2 " "	
9			22.2 " "	
10			22.2 " "	
Average			22.2 " "	2.70 seconds

Trial	Dia. of Ball	Mass of Ball	Amt. of Flow	Time of Fall
1	2.75 mm.	1.40 grams	22.3 cu. cm.	
2			22.5 " "	
3			22.5 " "	
4			22.7 " "	
5			22.7 " "	
6			22.7 " "	
7			22.5 " "	
8			22.6 " "	
9			22.3 " "	
10			22.4 " "	
Average			22.52 " "	2.74 seconds

STEEL BALLS.

Trial	Dia. of Ball	Mass of Ball	Amt. of Flow	Time of Fall
1	12.60 mm.	8.34 grams	21.1 cu. cm.	
2			21.1 " "	
3			21.2 " "	
4			21.1 " "	
5			21.1 " "	
6			21.1 " "	
7			21.1 " "	
8			21.1 " "	
9			21.0 " "	
10			21.1 " "	
Average			21.1 " "	2.56 seconds

Trial	Dia. of Ball	Mass of Ball	Amt. of Flow	Time of Fall
1	7.175 mm.	1.52 grams	21.5 cu. cm.	
2			21.5 " "	
3			21.5 " "	
4			21.6 " "	
5			21.6 " "	
6			21.8 " "	
7			21.9 " "	
8			21.8 " "	
9			21.5 " "	
10			21.5 " "	
Average			21.62 " "	2.63 seconds

Trial	Dia. of Ball	Mass of Ball	Amt. of Flow	Time of Fall
1	4.75 mm.	0.44 grams	22.2 cu. cm.	
2			22.4 " "	
3			22.6 " "	
4			22.3 " "	
5			22.5 " "	
6			22.3 " "	
7			22.1 " "	
8			21.9 " "	
9			22.2 " "	
10			22.4 " "	
Average			22.29 " "	2.71 seconds

An examination of the above data shows that within the range of size of the balls used in the experiment that an increase in diameter of similar balls results in a slightly increased velocity in falling.

The writers wish to express their thanks to Mr. A. B. Crowe of the physics department, for loan of apparatus and helpful suggestions during the progress of the investigation.

CITY WATER SUPPLIES AND THE NATIONAL FORESTS.

Secretary Wilson has decided that the interests of cities and towns which obtain their water from streams having their water sheds within national forests call for special measures of protection, and he has therefore developed a plan of co-operation for the Department of Agriculture with those communities which are alive to the importance of keeping their water supply pure.

There are many Western towns and cities, some of them of large size, which derive their water from drainage basins lying inside the national forests. One of the recognized objects of forestry is to insure the permanence and protect the purity of municipal water supplies. As the forests are maintained for the benefit of the public, Secretary Wilson considers it the duty of his department to do all that it can, both to prevent the pollution of such supplies and to create or maintain conditions most favorable to a constant flow of clear water.

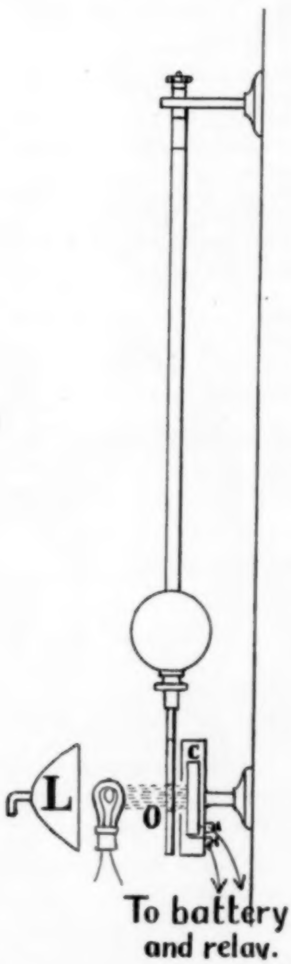
Stock raising and occupancy of the land for the various kinds of use which are ordinarily encouraged on the national forests may be highly undesirable if allowed on drainage basins which are the sources of drinking water. There is also to be considered the injury which may be done if the water is silt-laden. By protecting and improving the forest cover and by enforcing special regulations to minimize erosion and to provide for the maintenance of sanitary conditions, the government will try to safeguard the interests of the public.

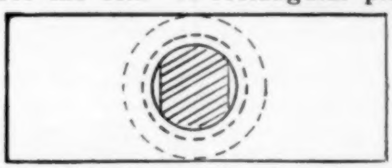
A form of agreement has been drawn up, providing for co-operation between the department and cities concerned, in which the government promises all possible protection of the water supply in return for the assumption by the city of a part of the extra expense necessitated.

THE SELENIUM CELL AS A CONTACT MAKER.

By Phillip Fitch,
North Side High School, Denver, Col.

One of the many uses to which the selenium cell can be put is to make the contact for a recording pendulum, and by its use, for this purpose, many of the objectionable features of the mercury and magnetic contact makers are obviated. The writer constructed a small selenium cell, which was fairly sensitive, and mounted it in a circular ebonite case in the lid of which a circular hole was cut in order to expose the cell. A rectangular plate





of Russian iron with a length equal to that of the swing of the pendulum and width slightly greater than the diameter of the case was taken and a circular hole cut in it, using the intersection of the diagonals as a center. The diameter of this hole was two mm. less than the diameter of the hole in the lid. This plate was then soldered to the lower end of a pendulum rod in such a manner that its plane was in the plane of the motion of the pendulum. The case was mounted on a support and so placed that the hole in the lid was parallel and opposite to the hole in the plate when the pendulum was in a vertical position. A sixteen candle-power incandescent lamp, supplied with a parabolic reflector, was placed in front of the plate and in line with the two holes. After joining the cell and a relay in circuit with a proper battery, the apparatus was ready to use. Twenty-six Le Clanche' cells, ar-

ranged in series, were necessary to produce the desired effect.

After the pendulum bob had been properly adjusted and the pendulum set in motion, the cell was exposed once per second to the light from the lamp. When the maximum surface of the selenium was exposed, the reduction in its resistance was just enough to allow the current to become sufficiently strong to operate the relay.

AN ELECTRICAL EXPERIMENT.

By Elmer E. Burns,
Joseph Medill High School, Chicago.

I found the following experiment described by one of the old masters in physics. It has proven so interesting to my classes that I repeat it every year. It suggests a possible explanation of the large drops of rainfall during the beginning of a thunder storm. The teacher may find it a profitable exercise to attempt to explain the phenomenon.

A glass tube is drawn into a pipette form with an opening of from one to two millimeters. This glass tube is connected to a water faucet by means of rubber tubing. The glass tube is pointed upward over a sink and the water gradually turned on until it rises to a height of about six feet. If the tube has been rightly prepared the water will rise in a jet and fall in a fine spray. If an electrified stick of sealing wax or vulcanite rod is brought near to the jet the spray will cohere and fall in great globules of water. The effect is plainly seen when the electrified rod is five or six feet from the jet but the nearer the rod is brought the greater is the cohering effect.

The jet can be made to sway to and fro by moving the rod near it. The experiment may be modified in a variety of ways such as the use of positively and negatively electrified rods at the same time, on the same side and on opposite sides of the jet.

ACID PROOF FINISH FOR TABLE TOPS.

By Franklin T. Jones.

All foreign substances must be thoroughly removed from the table top as the finish will not take except where the wood is fresh and clean.

Solution 1.

Copper Sulphate C P	125 gm.
Potassium Chlorate C P	125 gm.
Distilled Water	1000 cc.

The above is equivalent to a saturated hot solution of $CuSO_4$ and $KClO_3$.

Solution 2.

Anilin Hydrochlorate C P 150 gm.
Distilled Water 1000 c.
Soluble in the cold.

Apply two coats of 1 hot and rapidly. (Little change in color of wood.)
Then apply one or two coats of 2. (Color is a sickly green).
Let dry thoroughly.
Scrub with hot soap suds.
Let dry.
Wipe off with a cloth carrying some linseed oil. (Color is a fine black).

This prescription was first recommended to me by The Bausch and Lomb Optical Co. I have had occasion to apply it a number of times and it has always rendered the best of satisfaction.

THE HIGH SCHOOL BOTANICAL CLUB.

By Willard N. Clute.
Joliet, Ill.

It is not to be expected that every subject taught in the high school can be made so attractive that pupils will be inclined to continue it after the course has been completed, but among those that do occasionally command this interest in adult life, none has a more prominent place than botany. Indeed, the objects with which it deals are so attractive in themselves and the pursuit of these objects is so fraught with pleasurable experiences in field, wood, and garden that many who have never studied the subject in school have taken it up by themselves and became accomplished botanists. It is therefore to be expected that when properly taught it will appeal very strongly to the young student who, if normal, may be assumed to have a lively interest in all sorts of outdoor activities. With a little encouragement his interest in plants may be made permanent and the student started on a course that will afford him a pleasant pastime for his leisure hours and bring him much enjoyment and profit throughout his life.

It is a matter of common experience that students enjoy their work more and get better results when several are working together on the same problem than they would if working alone and this principle is often made use of in the laboratory by giving a group of students an experiment to perform or a problem to solve. In the same way a botanical club may serve to develop any latent interest in the subject of botany and to stimulate good students to increased activity. This may result in good to the whole community by inspiring a greater interest in parks and public playgrounds, the preservation of spots of historic interest or scenic beauty, and the general improvement of the locality. The writer knows of several clubs of this kind that have existed long enough to prove their worth and confidently expects to see a great increase in their numbers when their value is better known. Nor need the teacher conclude that in forming such a club he is working solely for the good of others. He may not be benefited botanically by such a course but his reward is none the less certain and comes with the development about him of a group of young people interested in the things in which he is interested and capable of discussing intelligently with him his special problems.

The wise teacher will probably let the organization of such a club depend largely upon the efforts of the pupils themselves. If there are not enough students to push the project through to a successful issue after it has been explained to them, it had better be abandoned until there are a sufficient number. This difficulty, however, is seldom encountered since a large society at the start is not desirable; in fact it is seldom worth while to strive for mere numbers. Better half a dozen members thoroughly interested than five times as many that must constantly be urged to do their part. A club can profitably be organized if there promises to be a membership large enough to fill all the offices.

Experience would also indicate that the club should be officered and run by the pupils themselves, the teacher acting simply in an advisory and judicial capacity. It also seems advisable to restrict the membership to those who have shown some proficiency in botany instead of throwing it open to all who may apply. This is upon the supposition that a pupil who does not have a mark of at least 85 for one semester's work in the subject is not sufficiently interested to make a desirable member. For similar reasons it is usual to adopt a rule that members absent from three regular meetings without good excuse shall be dropped from the rolls. Without some such rule the club is likely to find itself burdened with a large number of pleasure-loving members especially if it is active in promoting field trips, camping parties, and the like. In most cases the dues are quite low—not more than 25 or 50 cents a year—the necessary funds for special occasions such as banquets or excursions being raised by special assessments upon the members taking part. In some clubs the treasury is depended upon for a certain per cent of such expenses.

It is usual to have stated meetings once or twice a month for the reading and discussion of papers. These are usually held after school but may be held in the evening if circumstances warrant. In addition to the regular meetings, extra meetings for the celebration of special events may be held. At least one banquet should be held annually for the rounding up of the year's work and perhaps a reception to the new members if these are elected to membership at stated times, say at the beginning of the term.

The program at regular meetings is usually based upon one of two distinct types. In the one, members purchase the book agreed upon by the club and discuss it, chapter by chapter, after the manner of the well-known Chautauqua Circle. In the second, and

much better plan when it can be carried out successfully, the students write and present the papers, being helped thereto by the suggestions and advice of the teacher. A variety of subjects for papers will at once present themselves to the mind of the latter. Students who have visited distant lands may speak of the curious plants seen, the rare fruits of the markets may be discussed, while the spices, dyes, drugs, fibers, oils, gums, perfumes, etc., found in store and market and museum will form an endless list of subjects for investigation in the library. The botanists of the region may be called upon for instructive talks while the teacher of botany should be depended upon to fill any gaps in the program that may occur. As much as possible, however, the papers should be based upon the original observations of the pupils. Those with a taste for field work may take up a plant family for careful study, and the rare plants of the region may be exhibited and their peculiarities dwelt upon. Those who have a taste for microscopic work may take up such subjects as the shape of cells, forms of pollen grains, plant hairs, structures found in cells, and the like, illustrating their remarks by drawings of the objects described. The rock upon which many clubs split is the difficulty of getting enough good papers for the programs. As a means to this end it is often required that each new officer present a paper before the other members of the club are called upon to do so.

Botany being largely an out-of-door study the club will make no mistake in promoting all sorts of activities in the open air such as picnics, skating parties, straw rides, nutting parties, field trips, and camping parties. On pleasant Saturdays in the milder parts of the year, excursions may be made to points of local botanical interest, while in winter the city greenhouses and museums may be visited. Many of the trips suggested can scarcely be classed as botanical but are warranted by the interest in the main subject which their association with it stirs up. The club will be found to exert a wholesome effect upon the study of botany in the school, most pupils being not only willing but anxious to do good work in order to secure an election to the club. A botany class interested in the subject practically teaches itself and while the object of getting into the botanical club may not be the highest motive that might actuate the student, one may take advantage of it, trusting to a greater familiarity with this delightful science to inspire a more worthy interest.

PROBLEM DEPARTMENT.

BY E. L. BROWN.
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

259. *Proposed by R. E. Bowman, Alliance, O.*
Solve:

$$\left(3-\frac{6y}{x+y}\right)^2+\left(3-\frac{6y}{x-y}\right)^2=82. \qquad (1).$$

$$xy=2. \qquad (2).$$

I. *Solution by Richard Morris, New Brunswick, N. J.*
Eliminating y we get

$$\left(\frac{3x^2-6}{x^2+2}\right)^2+\left(\frac{3x^2-18}{x^2-2}\right)^2=82$$

or $$8x^4-23x^2-4=0.$$

$$x^2=(23\pm\sqrt{657})/16.$$

$(23+\sqrt{657})/16$ will give the *real* values, $\pm\frac{1}{4}\sqrt{23+\sqrt{657}}$, for x. The other value of x^2 makes x imaginary, since $\sqrt{657}>23$. Since $y=\frac{2}{x}$,

$$y=\pm\tfrac{1}{2}\sqrt{2(\sqrt{657}-23)}.$$

Hence $x=\pm1.7434$, and $y=\pm1.14718$.

II. *Solution by A. M. Harding, Fayetteville, Ark.*
N. B.—I have changed a sign in the last parenthesis in eq. (1). It seems to me that the problem is incorrectly stated.
Combine terms in eq. (1) and obtain

$9\left(\frac{x-y}{x+y}\right)^2+9\left(\frac{x+y}{x-y}\right)^2=82.$ Complete the square

$$9\left(\frac{x-y}{x+y}\right)^2+18+9\left(\frac{x+y}{x-y}\right)^2=100$$

$$3\left[\frac{x-y}{x+y}+\frac{x+y}{x-y}\right]=\pm10 \text{ or } \frac{3(x^2+y^2)}{x^2-y^2}=\pm5 \qquad (3)$$

Likewise by subtracting 18 from both sides of (1)

$$3\left[\frac{x-y}{x+y}-\frac{x+y}{x-y}\right]=\pm8$$

i. e. $\frac{-12xy}{x^2-y^2}=\pm8$ or $x^2-y^2=\mp3$ since $xy=2$

Now from (3) $x^2+y^2=\mp5$

$\therefore x^2=-4, -1, +4, +1$

or $x=\pm2i, \pm i, \pm2, \pm1.$ $\qquad i\equiv\sqrt{-1}$

$\therefore y=\mp i, \mp2i, \pm1, \pm2.$

265. Show that $(a+b)^4$ will not be equal to a^4+b^4, unless $ab=2(a+b)^2$, asuming that neither a nor b is zero. (Harvard entrance examination, June, 1909.)

Solution by H. H. Downing, Lexington, Ky., and J. G. Gwartney, Orosi, Cal.

$$(a+b)^4=a^4+4a^3b+6a^2b^2+4ab^3+b^4$$
$$=a^4+b^4+2ab(2a^2+3ab+2b^2)$$
$$=a^4+b^4+2ab[2(a+b)^2-ab]$$

Hence $(a+b)^4=a^4+b^4$ when and only when

$$2ab[2(a+b)^2-ab]=0.$$

Since $a\neq 0$, $b\neq 0$, therefore $2ab\neq 0$ and $2(a+b)^2-ab$ must be zero. This gives $ab=2(a+b)^2$.

266. *Proposed by H. E. Trefethen, Waterville, Me.*

Given $2\sqrt{xy}=\sqrt{r(r-2x)}-y$ (1) and $y=r(\sqrt{2}-1)$. (2)

Show that $\dfrac{x}{y+2\sqrt{xy}}=\dfrac{1}{7}$.

I. *Solution by I. L. Winckler, Cleveland, O.*

From the second given equation,

$$r=y(\sqrt{2}+1)\ldots\ldots\ldots\ldots\ldots(3)$$

From (3) and the first given equation.

$$y+2\sqrt{xy}=\sqrt{y^2(3+2\sqrt{2}-2xy(\sqrt{2}+1)}$$

Squaring, reducing, and factoring,

$$(y+\sqrt{xy})[(\sqrt{2}+1)y-(3+\sqrt{2})\sqrt{xy}]=0.$$

Equating each factor to zero,

$$y+\sqrt{xy}=0,\text{ and }(\sqrt{2}+1)y-(3+\sqrt{2})\sqrt{xy}=0.$$

The first of these equations gives $x=y$, which does not satisfy the first given equation.

From the second, $x=\dfrac{y(9+4\sqrt{2})}{49}$ ......(4). This satisfies (1).

From (1) and (4) $$\frac{x}{y+2\sqrt{xy}}=\frac{\dfrac{y(9+4\sqrt{2})}{49}}{\dfrac{y(9+4\sqrt{2})}{7}}=\frac{1}{7}$$

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Since $y+2\sqrt{xy}=\sqrt{r(r-2x)}$ then $\dfrac{x}{y+2\sqrt{xy}}=\dfrac{x}{\sqrt{r(r-2x)}}$;

that is we must show that $\dfrac{x}{\sqrt{r(r-2x)}}=\dfrac{1}{7}$.

Substituting $y=r(\sqrt{2}-1)$ in $y+2\sqrt{xy}=\sqrt{r(r-2x)}$, we easily obtain

$$[(9-4\sqrt{2})x-r(\sqrt{2}-1)][x-r(\sqrt{2}-1)]=0.$$

$$\text{Whence}\quad x=\frac{r(\sqrt{2}-1)}{9-4\sqrt{2}}\text{ or }r(\sqrt{2}-1).$$

Substituting these values of x in $\dfrac{x}{\sqrt{r(r-2x)}}$ we get

$$\frac{x}{\sqrt{r(r-2x)}}=\frac{1}{7}\text{ or }1.$$

Both conditions are true, provided we admit that the radical has a double sign in the original expression.

The desired result may also be obtained by forming the equations with rational coefficients that have for one root

$$x=\frac{r(\sqrt{2}-1)}{9-4\sqrt{2}} \text{ or } r(\sqrt{2}-1).$$

The equations are:

$$49x^2=r^2-2rx, \text{ and } x^2=r^2-2xr.$$

$$\text{Whence } \frac{x}{\sqrt{(r-2x)r}}=\frac{1}{7} \text{ and } \frac{x}{\sqrt{r(r-2x)}}=1.$$

Remark by R. M. Mathews, Chicago, Ill.

The relation (2) is not the only one by means of which (3) may be deduced from (1). For solving (3) for x in terms of y we find

$$(4) \qquad x=y\,\frac{(9\pm4\sqrt{2})}{49};$$

and solving (1) and (3) together for x in terms of r we get

$$(5) \qquad x=r\,\frac{(-1\pm5\sqrt{2})}{49}.$$

Elimination of x between (4) and (5) gives

$$y=r\,\frac{(-1\pm5\sqrt{2})}{9\pm4\sqrt{2}},$$

and the two ambiguous signs are independent of each other. Thus there are four possible relations of form (2) for y and r, namely:

$$y=r(\sqrt{2}-1),\ r\,\frac{(31+41\sqrt{2})}{49},\ r\,\frac{(31-41\sqrt{2})}{49},\ -r(\sqrt{2}+1).$$

Geometry.

267. *Proposed by O. Price, Denver, Colo.*

P is a point on the minor arc AB of the circumcircle of the regular hexagon ABCDEF; prove that PE+PD=PA+PB+PC+PF.

I. *Solution by H. H. Seidell, St. Louis, Mo., and I. L. Winckler, Cleveland, O.*

On PD take PH=PF, and on PE take PG=PC.

Then $\triangle$FPB=$\triangle$FHD.

For $\angle$FPD=60°, and since PH=PF, $\angle$PFH=$\angle$PHF.

$\therefore$ $\triangle$PFH is equiangular and $\therefore$ equilateral, and PF=FH.

Also FB=FD, since arc FAB= arc FED.

$\because$ $\angle$DFH+$\angle$BFH=60°, and $\angle$PFB+$\angle$BFH=60°.

$\therefore$ $\angle$DFH=$\angle$PFB.

$\therefore$ HD=PB.

Similarly GE=PA, by proving $\triangle$APC=$\triangle$GEC.

$\therefore$ PE+PD=PC+PA+PF+PB.

II. *Solution by Editor.*

In any inscribed quadrilateral the product of the diagonals equals the sum of the products of the opposite sides. Hence

In PAEC, PE·AC=PA·EC+PC·AE. (1)

In PBDF, PD·BF=PB·FD+PF·BD. (2)

Clearly AC, BF, EC, FD, AE, and BD are equal.

$\therefore$ adding (1) and (2) we have

PE+PD=PA+PB+PC+PF.

268. *Selected.*

The diagonals AC, BD of a quadrilateral ABCD meet at K; prove that the circumcenters of the triangles KAB, KBC, KCD, KDA are the vertices of a parallelogram.

Solution by J. M. Townsend, South Braintree, Mass., and Jennie K. Bresel, New York City.

Let E, F, G, H be the centers of the circumcircles of triangles AKB, BKC, CKD, DKA, respectively. Since AK is a common chord of the circles whose centers are E and H, HE $\perp$ AC.

Similarly GF $\perp$ AC. $\therefore$ HE $\parallel$ GF.

In a similar manner EF $\parallel$ HG.

$\therefore$ EFGH is a parallelogram.

269. *Proposed by W. P. Russell, Claremont, Cal.*

Having a cylindrical tank on its side resting on a horizontal plane, required the depth to which it must be filled to contain a certain number of gallons.

I. *Solution by H. E. Trefethen, Waterville, Me.*

If no table of areas and heights of segments in unit circle is at hand, the following method may be used.

Let O be the center and AB the water line on one end of the tank. Put r = the radius and x = the arc AB. Then area of sector AOB = $\frac{1}{2}r^2x$, area of triangle AOB = $\frac{1}{2}r^2\sin x$. Hence if we put the area of minor segment AB$=kr^2$, which is readily found, since the area of the segment covered with water is to the area of the circle as the required number of gallons is to the full capacity of the tank. If the tank is more than half full, the difference of these will be the area of the minor segment. Hence in either case we may put

$$1/2\, r^2x - 1/2\, r^2 \sin x = kr^2 \text{ or } x - \sin x = 2k \qquad (1)$$

Now put $x=f+z$, f being an assumed arc as near to the value of x as can be estimated. Then the $\sin x = \sin(f+z) = \sin f \cos z + \cos f \sin z$. Put $\sin f = m$, $\cos f = n$, $\cos z = 1 - z^2/2 + z^4/|\underline{4} -$etc., $\sin z = z - z^3/|\underline{3} +$ etc. Substituting in (1) we have

$$f+z-m+mz^2/2-mz^4/|\underline{4}-nz+nz^3/|\underline{3}=2k \text{ or}$$
$$mz^4/|\underline{4}-nz^3/|\underline{3}-mz^2/2+(n-1)z+2k+m-f=0.$$

z is readily found by Horner's method, when we have numbers for f, k, m, n. If a closer approximation is desired, put $f+z=f_1$ and proceed as before.

The required depth $=r+r\cos(x/2)$, the double sign being taken according as the tank is more or less than half full.

II. *Solution by A. M. Harding, Fayetteville, Ark.*

Let O be the center and AB the water line on one end of tank.

Let a=radius of cylinder in inches,
d=depth of liquid in inches,
l=length of tank in inches,
2θ=angle AOB,
c=capacity of tank in gallons,
g=no. of gallons required.

We have $[\frac{1}{2}a^2\theta - \frac{1}{2}(a-d)\sqrt{2ad-d^2}]l = \frac{1}{2}$ vol. of liquid $= \dfrac{231g}{2}$.

$$\therefore \theta - \frac{a-d}{a}\cdot\frac{\sqrt{2ad-d^2}}{a} = \frac{231g}{la^2} = \frac{\pi g}{\dfrac{\pi l a^2}{231}} = \frac{\pi g}{c}.$$

$$\text{or } \theta - \tfrac{1}{2} \sin 2\theta = \frac{\pi g}{c} \qquad (1)$$

Now from a table of natural trigonometric functions we can easily find θ *by trial.*

After finding θ we can find d from the equation $\cos \theta = \frac{a-d}{a}$.

NOTE.—We must use radians and not degrees.

Examples. Suppose $l=60$ in., $a=20$ in., $c=326.4$ gals.

(1) Let $g=100$ gallons.

We obtain $\theta - \tfrac{1}{2}\sin 2\theta = 0.9625$.

Let $\theta = 72^\circ = 1.2566$ radians.

We have $1.2566 - \tfrac{1}{2}(0.5878) = 0.9627$.

$\therefore \theta = 72^\circ$ is a very close approximation.

$\operatorname{Cos} 72^\circ = \frac{0.3090}{1} = \frac{a-d}{a} \quad \therefore d = (0.6910)a = 13.82$ inches.

(2) Equation (1) holds even when $g > \tfrac{1}{2}c$, in which case $\theta > 90^\circ$.

Let $g=200$ gallons; then $\theta - \tfrac{1}{2} \sin 2\theta = 1.9250$.

When $\theta = 100^\circ 15'$ we have $1.7497 - \tfrac{1}{2}(-0.3502) = 1.9253$.

$\operatorname{Cos} \theta = -\frac{0.1779}{1} = \frac{a-d}{a}$.

Whence $d = (1.1779)a = 23.558$ inches.

Trigonometry.

269a. *Proposed by H. E. Trefethen, Waterville, Me.*

Show that the squares of the sides of a triangle are in arithmetical progression, if the contangents of the angles are in arithmetic progression.

Solution by R. M. Mathews, Chicago, Ill.

Let C, B, A be the angles of any triangle arranged in descending order of magnitude. Then by the law of cosines

$$\cos C = \frac{a^2+b^2-c^2}{2ab}, \quad \cos B = \frac{a^2+c^2-b^2}{2bc}, \quad \cos A = \frac{b^2+c^2-a^2}{2bc}.$$

If D be the diameter of the circumcircle, then by the law of sines: $\sin C = c \cdot D$, $\sin B = b \cdot D$, $\sin A = a \cdot D$.

Consequently

$$\cot C = \frac{a^2+b^2-c^2}{2abc\,D}, \quad \cot B = \frac{a^2+c^2-b^2}{2abc\,D}, \quad \cot A = \frac{b^2+c^2-a^2}{2abc\,D}.$$

By hypothesis these functions are in arithmetic progression, so cot B is the arithmetic mean between cot C and cot A.

$$\therefore \quad \cot C + \cot A = 2 \cot B,$$

$$\text{gives} \quad a^2+c^2=2b^2.$$

But this last equation says that b^2 is the arithmetic mean between a^2 and c^2.

Remark. It is of interest to inquire what relation holds if the *squares* of the cotangents be in arithmetic progression. By means of the relations above, we find that

$$\cot^2 C + \cot^2 A = 2 \cot^2 B$$

$$\text{implies} \quad b^2c^2 + a^2b^2 = 2a^2c^2.$$

This may be expressed: If the squares of the cotangents of the angles of a triangle be in arithmetic progression and the sides in order be a, b, c, then the squares of the cyclic products in pairs, namely:

b^2c^2, c^2a^2, a^2b^2

are in arithmetic progression.

CREDIT FOR SOLUTIONS RECEIVED.

259. R. E. Bowman, A. M. Harding, Richard Morris. (3)
260. S. F. Atwood, T. M. Blakslee, A. M. Harding, G. I. Hopkins, Gertrude L. Roper. (5)
261. A. M. Harding, Orville Price. (2)
262. A. M. Harding, H. E. Trefethen. (2)
263. Olaf K. Lie. (1)
264. H. E. Trefethen. (1)
265. T. M. Blakslee, E. G. Berger, Jennie K. Bresel, C. D. Donaldson, H. H. Downing, John M. Gallagher, J. G. Gwartney, A. M. Harding, Irvin E. Kline, R. M. Mathews, H. G. McCann, C. A. Perrigo, Nelson L. Roray, H. H. Seidell, Elmer Schuyler, J. M. Townsend (2 solutions), H. E. Trefethen, I. L. Winckler. (19)
266. C. D. Donaldson, A. M. Harding, G. I. Hopkins, Irvin E. Kline, R. M. Mathews, T. E. Peters, Nelson L. Roray, H. H. Seidell, Elmer Schuyler, H. E. Trefethen, I. L. Winckler. (11)
267. Jennie K. Bresel, E. L. Brown, H. H. Downing, A. M. Harding, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, J. M. Townsend, H. E. Trefethen, I. L. Winckler. (10)
268. Jennie K. Bresel, H. H. Downing, A. M. Harding, H. G. McCann, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, J. M. Townsend, H. E. Trefethen, I. L. Winckler. (10)
269. A. Dawkins, A. M. Harding, Nelson L. Roray, H. E. Trefethen. (4)

269*a*. Jennie K. Bresel, H. H. Downing, A. M. Harding, Nelson L. Roray, H. H. Seidell, Elmer Schuyler, J. M. Townsend, H. E. Trefethen, I. L. Winckler. (9)

Total number of solutions, 72.

PROBLEMS FOR SOLUTION.

Algebra.

277. *Proposed by Ruby Albert, Denver, Colo.*

Solve by quadratics:

$$3xy-4x-4y=0 \qquad (1)$$
$$x^2+y^2+x+y-26=0 \qquad (2)$$

278. *Selected.*

For what values of x is

(*a*) $\dfrac{a+x}{a-x}+\dfrac{a-x}{a+x}$ a minimum;

(*b*) $(x^2+2x+1)(7-x^2-2x)$ a maximum?

Geometry.

279. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Given the three diagonals of an inscriptible quadrilateral, to construct the quadrilateral.

If the internal diagonals are 10 and 12 and the external is 20, what are the lengths of the sides?

280. *Proposed by D. A. Lehman, Goshen, Ind.*

Prove that the dihedral angle of a regular octahedron is the supplement of the dihedral angle of a regular tetrahedron.

281. *Proposed by H. H. Downing, Lexington, Ky.*

Prove:

(*a*) The sum of the squares of the lines drawn from any point of a circle to the angular points of a regular inscribed polygon of n sides is equal to $2nR^2$.

(*b*) The sum of the squares of all the lines of connection of the angular points of a regular polygon of n sides, inscribed in a circle of radius R, is n^2R^2.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Our readers are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Examination Questions in Physics.

The following set of questions was used at a term examination at University School in December, 1911. Twelve only took this examination, of whom four stood 90 or above; one stood 88; four between 70 and 80; two between 60 and 70; one stood below 60. As in examinations for college entrance, the passing mark was taken as 60 and the papers marked with corresponding rigidity.

As always, there was some confusion in ideas. The chief obstacle to success was a command of clear and idiomatic English in which to express ideas.

1. State the facts concerning the acceleration, velocity, and distance traveled for a falling body.
2. How high is a balloon from which a body would fall to the earth in 10 seconds? With what velocity would it strike?
3. What is force? inertia? momentum? energy? work? Explain the differences between force and work; work and energy.
4. Explain why a pendulum is used in a clock. Explain how a pendulum illustrates transformation of energy.
5. State the principle of the parallelogram of forces and explain its application in the inclined plane. Does an inclined plane help to decrease the work done? Explain.
6. Describe the use of a lever to pry up a stone. State the law of the lever. Compare the wheel and axle with the lever.
7. Define specific gravity. Explain how to calculate the specific gravity of any substance. Describe how to determine the specific gravity of a piece of tin.
8. Describe the hydraulic press. Explain why water runs from a hydrant.
9. Why is gravity greater at the poles than at the equator? Give two reasons.
10. State Boyle's Law. Explain why the atmosphere is densest near the earth's surface.

Solutions.

Proposed by E. Carl Watson, Lafayette, Ind.

What are the proper dimensions for resonance boxes to give best results with forks C_1, D, E, F, G, A, H, C_2?

Answer by Wm. Gaertner of Wm. Gaertner & Co., Instrument Makers, Chicago, Ill.

In respect to information on resonance boxes I regret to say that we have never thoroughly studied this problem. We have been making our boxes of the same dimensions as these of Dr. Edelmann, München, Germany. With these boxes you are no doubt familiar, but I send you below the sizes in millimeters.

C_1	297 mm.	x 81 mm.	x 43 mm.
D	258 mm.	x 81 mm.	x 43 mm.
E	232 mm.	x 81 mm.	x 43 mm.
F	219 mm.	x 81 mm.	x 43 mm.
G	190 mm.	x 81 mm.	x 43 mm.
A	166.1 mm.	x 81 mm.	x 43 mm.
H	153 mm.	x 62 mm.	x 36 mm.
C_2	142 mm.	x 62 mm.	x 36 mm.

I understand that in order to get the maximum intensity of a resonance box the length should be a multiple of the wave length of the note for which it is to be used. In this case the box will vibrate together with the fork and give a very strong sound, but of short duration. Since it is usually more desirable to have a long vibrating fork we cut the boxes slightly shorter than they should be according to theory and obtain longer vibration.

We have measured other boxes from different European makers, Dr. Edelmann, Max Kohl and Koenig, etc., but no two are alike and there is a difference of as much as about five per cent in length.

66. *Proposed by O. R. Sheldon, Chicago, Ill.*

A match may easily set fire to a shaving, but not to a block of the same material. Why?

Answer by the Editor.

The heat of the match is sufficient in amount and intensity to start the distillation of gases whose combustion is commonly regarded as the burning of the wood. The heat is sustained by the combustion of these gases until the whole shaving is afire. In the case of the block the match does not supply heat enough to raise the temperature to the distillation point.

ARTICLES IN CURRENT PERIODICALS.

American Botanist for November: "The Smooth or Meadow Phlox," Willard N. Clute; "November Waifs," Dr. W. W. Bailey; "Asters," B. O. Wolden; "Root Punctured by Root," Charles E. Bessey.

American Forestry for December: "Building the World's Highest Dams," C. J. Blanchard, with four illustrations; "Studies for Reforestation," A. G. Hamel, with four illustrations; "Logging on a National Forest," Sidney L. Moore, with eight illustrations; "Penn State College Outlines a New Undergraduate Course in Forestry," H. P. Baker, with five illustrations; "Scientific Management and the Lumber Industry," R. C. Bryant; "Disposal of Fire-Killed Timber on the Sopris National Forest," John McLaren; "Vermont Summer School of Forestry and Horticulture," R. A. Chandler, with four illustrations.

American Naturalist for December: "The Inheritance of Color in Short-horn Cattle," H. H. Laughlin; "Studies on Melanin," Dr. Ross Aiken Gortner.

Education for December: "The Public School Course of Study," S. S. Stockwell; "The Mission of the Private School," Nelson A. Jackson; "Training for Social Efficiency," Laura H. Wild; "The Supervision of Teachers," E. H. Fishback.

Educational Psychology for December: "The Aims, Values, and Methods of Teaching Psychology in a Normal School," J. Mace Andress; "On Methods of Mental Measurement, Especially in School and College," A. P. Weiss; "Pedagogical Problems in Nature Study," Frederick L. Holtz.

Journal of Geography for December: "The Importance and Possibilities of Geography in Elementary Schools," A. C. Bowen; "The General Circulation of the Atmosphere," Annie L. Weller; "The World's Great Rivers—The St. Lawrence," V. C. Finch; "Commerce of the World in 1910;" "The Jordan Valley," Frederick Homburg.

L'Enseignement Mathématique for November: "Commission internationale de L'enseignement mathématique: Compte rendu du Congrès de Milan (18-21 septembre, 1911) publié par H. Fehr. secrétaire-général de la Commission."

Mathematical Gazette for December: "The Aim and Method of School Algebra," T. P. Dunn; "The Theory of Order, as Defined by Boundaries," E. T. Dixon; "The 'Meraner Lehrplan' Mathematical Curriculum for Gymnasia," translated by E. A. Price.

Popular Astronomy for January: "Solar Halos of November Third," Frederick Slocum; "Peculiar Movements of the Sun, Earth, and Stars," John Candee Dean; "Solar and Lunar Declination," Frederick Campbell; "Review of Poincaré's Lectures on Cosmogony," T. J. J. See; "A Modern Look at the Universe," Henry Olerich; "The Occultations of Mars of January 1 and 28, 1912, as Visible in the United States."

Popular Science Monthly for December: "Science among the Chinese," C. K. Edmunds; "Why do Certain Living Forms Produce Light?" F. Alex. McDermott; "The Water Relations of Desert Plants," D. T. MacDougal; "Buffon and the Problem of Species," Arthur O. Lovejoy; "Protozoan Germ Plasm," Gary N. Calkins; "Adamas, or the Symmetries of Isometric Crystals," B. K. Emerson; "The Lack of Printing in Antiquity," Frederic Drew Bond; "Is Vegetarianism Capable of World-wide Application?" Alonzo Engelbert Taylor.

Photo-Era for December: "A Few Remarks on Home-Portraiture with Artificial Light," Nathan T. Beers; "The Need of Legal Restrictions on the Publication of Photographs," Henry Leffman; "A Poet of Sunshine and Mist—A Recorder of Atmosphere: Maude Wilson," Sidney Allan; "Practical Retouching for Amateurs," Clara Weisman; "Seeing Things Correctly—A Lesson on the Judging of Color-Values," William J. Edmondson; "Artistic Interiors," E. H. Weston.

Physical Review for November: "An Absolute Determination of the Minimum Ionizing Energy of an Electron, and the Application of the Theory of Ionization by Collision to Mixtures of Gases," Edwin S. Bishop; "Studies in Luminescence. XVI. The Fluorescence and Absorption of Certain Uranyl Salts," Edw. L. Nichols and Ernest Merritt; "Determination of Peltier Electromotive Force for Several Metals by Compensation Methods," A. E. Caswell; "The Recovery of the Giltay Selenium Cell and the Nature of Light Action in Selenium," F. C. Brown; "Thermal Conductivity at High Temperatures," M. F. Angell; "On the Fatigue of Metals Subjected to Roentgen Radiation, in the Presence of Chemically Active Gases," Edward G. Rieman; "New Records of Sound Waves from a Vibrating Flame," Joseph G. Brown.

School Review for December: "The Disintegration of a High School Class," Freeman E. Lurton; "Some Aspects of the Child Welfare Problem in the New York High Schools," Benjamin C. Gruenberg.

School World for December: "An Experiment in Elementary Woodwork. II. (Illustrated)," T. S. Usherwood; "Geographical Books for the School Library," B. C. Wallis; "The Value of Science," Francis Darwin; "Personal Paragraphs," Onlooker; "The Teaching of Housecraft;" "The Health of the Children;" "Secondary Education in Scotland."

THE INTERNATIONAL COMMISSION ON THE TEACHING OF MATHEMATICS, SESSION AT MILAN.

The International Commission on the Teaching of Mathematics held its first regular session at Milan, Italy, September 18-21, 1911, a preliminary session having been held at Brussels, Belgium, in August, 1910. There were present the representatives of Austria, British Isles, Denmark, Germany, Hungary, Italy, Norway, Russia, Sweden, Switzerland. None of the American members was able to be present.

Reports of the state of advancement of the work in various nations were presented and plans were adopted for the session of the Commission in connection with the International Congress of Mathematicians to be held at Cambridge, England, in August, 1912. A central depository for all publications relative to the work of the Commission was established with Messrs. Georg and Co., Geneva, Switzerland, from whom any reports desired can be purchased. (It will be recalled that the American reports are now being published as Bulletins of the United States Bureau of Education, and can be obtained free upon request.)

The Commission also received and discussed the reports of two subcommissions appointed to consider the following questions: Subcommission A (Messrs. F. Klein, Göttingen, Germany, chairman; M. Beke Budapest, Hungary; C. Bioche, Paris, France; W. Lietzmann, Barmen, Germany; G. Scorza, Palermo, Italy; J. W. A. Young, Chicago, U. S. A.): I. To what extent can the work of secondary schools take account of systematic exposition of mathematics? II. The question of the fusion of the different branches of mathematics in secondary instruction.

Subcommission B (Messrs. F. Klein, Göttingen, Germany, chairman; C. Bourlet, Paris, France; H. Fehr, Geneva, Switzerland; C. Somigliana, Turin, Italy; P. Staeckel, Carlsruhe, Germany; W. Wirtinger, Vienna, Austria): How should the mathematical work of prospective students of physics and the natural sciences be organized, in order to lead them directly to their goal?

A full account of the session of the Commission is given in *L' Enseignement Mathématique*, November 15, 1911.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

The eighth annual meeting of this association was held Friday, Nov. 10, 1911, at Topeka, Kansas, in the Audience Room of the Unitarian Church. The meeting was called to order at 2 p. m. by the president, C. H. Ashton, of the University of Kansas.

Professor U. G. Mitchell of the University of Kansas spoke on "The Growth of Algebraic Symbolism." Preceding his lecture, he distributed copies of his booklet on the subject. He went into considerable detail concerning the development of symbolism and the reasons why it is interesting and helpful to trace the development.

Professor R. L. Short, Principal West Technical High School, Cleveland, Ohio, gave an address on "Mathematical Work in the Vocational Schools of Cleveland."

Professor W. A. Harshbarger of Washburn College, Topeka, Kansas, read a paper on "A Comparison of the Teaching of Elementary Mathematics in this Country and Europe." He used charts to make clear the points he brought out in his comparison.

These three papers were followed by a general discussion upon the above topics.

The last subject on the program was a "Note on the Quadratic" by Professor Short.

The membership remains practically the same as last year. A good list of subscriptions was taken for SCHOOL SCIENCE AND MATHEMATICS.

The officers for the ensuing year are:

President, W. H. Andrews, State Agricultural College, Manhattan.

Vice-President, Fiske Allen, State Normal, Emporia.

Secretary-Treasurer, Eleanora Harris, High School, Hutchinson.

NORTH DAKOTA ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The fifth annual meeting of the North Dakota Association of Science and Mathematics Teachers was held at the University of North Dakota, Dec. 2, 1911. Sessions were held in the morning and afternoon, and forty members were in attendance.

The program consisted entirely of informal discussions of a previously announced series of topics, each of which was introduced by a brief paper or talk by some member to whom it had been assigned in advance. Speakers, except those introducing each heading, were limited to five minutes, and very spirited and helpful debates ensued. The relative place of botany and zoölogy in the high school course received especial attention.

The program included the following topics, and also others upon which less time was spent:

The Place of Physiology in the School Curriculum.

Botany and Zoölogy; is it better to offer in the High School a half year of each or a whole year of one?

The Need of Specimen or Supply Cabinets in the Public Schools.

To What Extent can Meteorology Conveniently be Taught in the High School? The Division of Time among Topics in Physiography.

Physics in the High School.

- Item: Uniformly Accelerated Motion, the bone of contention among teachers.
- Item: Can Wireless Telegraphy be understood by high school scholars?

Arithmetic in the grades: Are there Defects in the Final Result, or Undue Emphasis on Any Portions?

- Item: Square Root and Cube Root.
- Item: Lack of Accuracy in the Fundamental Operations.
- Item: Ratio and Proportion.
- Item: Neglect to develop the habit of using "Round Numbers" as a check on computations.

The Metric System is the System of More than Half the Civilized World; When and How Much Ought to be Taught Here?

Committees were appointed to report on physiography and some other topics. The following officers were elected for the ensuing year:

President, Principal W. C. Stebbins, High School, Grand Forks, N. D.

Vice-President, Professor E. G. Burch, State Science School, Wahpeton, N. D.

Secretary, Professor L. B. McMullen, State Normal School, Valley City, N. D.

E. F. CHANDLER, *Retiring President.*

REPORT OF THE SIXTIETH MEETING OF THE EASTERN ASSOCIATION OF PHYSICS TEACHERS.

This meeting was held Saturday, December 2, at the Howard University Observatory. It was called to order by President Griswold, who introduced Professor Pickering, director of the observatory, who gave a most interesting talk on what had been and what was being done, especially in the direction of photometry of the stars at this observatory.

A tour of inspection of the observatory grounds and buildings was participated in by all the members present. This part of the program was particularly enjoyable and interesting as the inner working of the department was explained.

Valuable reports from the standing committees on: New Apparatus, Magazine Literature and Current Events in Physics were presented. It is hoped that the committee on New Apparatus will prepare its report for publication in SCHOOL SCIENCE AND MATHEMATICS.

Several new members were elected to the Association.

Dr. Arthur Amadon of Boston delivered a splendid address on "The Uses of the Spectacle Lenses for the Correction of Refractive and Other Errors of the Eyes and the Instruments Used for Determining Such Errors." This was a most interesting and helpful talk. It is hoped that the paper will be published in this Journal.

Professor Harry W. Morse of Harvard University then spoke on the subject of "The Compound Microscope." He called attention to some of the newer adaptations of the Compound Microscope, explaining what remarkable advances had been made in the construction and uses of this instrument within the last ten years.

After this address the members were given the special privilege of being permitted to visit the renowned Clock Lens Works. Many interesting points of especial importance to physics teachers were here made known.

At the evening session, held at the Boston City Club, Vice-President Fred H. Cowan gave the annual address. He called attention to the different phases of work in which the Association has engaged and also to the valuable work which it has already done.

Following this address a discussion of the topic: "The Scope and Content of a Physics Course in Secondary Schools" was dealt with. On the whole this meeting was one of the most helpful ever held by the Association.

C. H. S.

STIRRING RODS.

By NICHOLAS KNIGHT,
Cornell College.

Instead of the ordinary solid rod we have used for years in our laboratory glass tubing three sixteenths or four sixteenths inch in diameter. These tubes are cut into convenient lengths and the ends fused together in the Bunsen burner or the blast lamp. These are lighter and stronger than the solid rod for the same reason that the cones are hollow. And they are less liable to break the beaker glass. Continued and vigorous stirring is desirable in many experiments in general chemistry. In qualitative and quantitative analysis the reactions often take place only after considerable stirring. "Spare the rod and spoil the analysis" is a very proper maxim for the analytical laboratory. The hollow rod is an obvious advantage and it will prolong the life of many a beaker glass and avoid beginning over again an experiment or an analysis.

NEW ENGLAND TREES IN WINTER.

Is the title of bulletin No. 69 just issued by the Storrs Agricultural Experiment Station of Connecticut, the authors being A. F. Blakeslee, Professor of Botany, Connecticut Agricultural College, and C. D. Jarvis, Horticulturist, Storrs Agricultural Experiment Station.

This bulletin has descriptions and illustrations of one hundred and eleven of the common trees of New England as they appear in winter. A tree in winter is quite a different proposition from the same tree in summer when the branches are all hidden by foliage. This bulletin not only describes the trees and their habits of growth, but the illustrations show the complete tree and its branching habits, the bark and buds and in many cases the seeds or fruit. All the illustrations are from original photographs of living trees, no museum specimens being used. In the preface the authors state there is no general work upon American trees which combines illustrations of the individual forms with keys for their identification based upon winter characters. The forester and lumberman, however, are more called upon to distinguish trees in winter when leaves and flowers are fallen, than in summer. Trees, as the most conspicuous elements in the winter landscape, must also appeal to the student of outdoor life.

The interest shown by classes of school teachers in the summer school in identifying specimens of twigs collected the previous winter indicated that the winter study of trees can be taken up with enthusiasm by teachers in their schools. In our experience, the winter identification of trees has proven to students one of the most interesting subjects of their course. It is of decided value for its training in the power of accurate observation. The work comes at a time when material for natural history study seems scanty and might therefore be used to bridge over the period between fall and spring which are unfortunately considered by many the only seasons when study of outdoor life is possible in the schools. A tree in winter is far from being the characterless object many believe. Freed from its covering of leaves, the skeleton of the tree is revealed and with the method of branching thus clearly discernible, the species may generally be more readily identified at a distance than in its summer garb. There are many forms, moreover, that are difficult to distinguish from summer features alone but which in winter have twig, bud, or other characters which make their separation comparatively easy. It is believed that the combination of keys, text, and illustrations from photographs will furnish assistance which the current texts fail to supply and render the identification of our common trees in winter a relatively simple task.

Upon request copies of this bulletin will be sent free to all teachers of Connecticut and to others who are specially interested in trees. Address Storrs Agricultural Experiment Station, Storrs, Conn.

OIL IN ALASKA.

Petroleum has been found in Alaska, and while there has been practically no production, it is not impossible, according to the United States Geological Survey, that commercial pools may be found. Oil seepages occur on the west shore of Cook Inlet, on the east side of the Alaska Peninsula, and on Controller Bay, all close to tidewater, and hence capable of cheap development.

BOOKS RECEIVED.

Wiadomosci Mathematyczne. Tom XV, 1911. Editor, S. Dickstein, Warszawa.

Elementoj de la Geometrio Absoluta. By Dro Cyrillo Vörös, Profesoro de L'piaj Lernejoj. Budapest. Paper. Pp. 104. 1911.

Analitika Geometrio Absoluta. Unua Volumo, La Ebeno Bolyai-a. Dua Voluma, La Spaco Bolyai-a. By same author. Paper. Pp. 132, 196. 1910-1911.

New England Trees in Winter, by A. F. Blakeslee and C. D. Jarvis. 271 pages. (See description on page 162.) Publishers, Storrs Agricultural Experimental Station, Storrs, Conn.

A Practical Course in Botany, by E. F. Andrews and Francis E. Lloyd. Pages xii+373. 15x21 cm. Cloth, 1911. American Book Company, New York.

Elementary Applied Mechanics, by Arthur Morley and William Inchley, viii+382. 13x19 cm. Cloth, 1911. Longmans, Green & Co., New York.

Elements of Religious Pedagogy, by Fred Lewis Pattee, Pennsylvania State College. 224 pages. 14x20 cm. Cloth, 1909. Eaton & Mains, New York.

Productive Farming, by Kary Cadmus Davis, New Jersey College of Agriculture. Pages viii+357. 14x19 cm. Cloth, 1911. J. B. Lippincott Company, Philadelphia.

Brief Course in Analytic Geometry, by J. H. Tanner and Joseph Allen. Pages, x+282+xxiv. 13x18 cm. Cloth, 1911. American Book Company, New York.

An Introductory Algebra, by John H. Walsh, Associate Supt. of Schools, New York. Pages ix+214. 13x18 cm. Cloth, 1911. D. C. Heath & Co., Boston.

BOOK REVIEWS.

Elements of Applied Mathematics, by Herbert E. Cobb, Professor of Mathematics, Lewis Institute, Chicago. Pages vii+274. Price $1.00, Ginn and Company, Boston.

All progressive teachers of mathematics in secondary schools will find a deep satisfaction in examining this book, because it is such an excellent embodiment of the reforms toward which we are striving in secondary mathematics teaching. We are coming more and more to see that in past teaching the formal, abstract, and purely theoretical phases of the mathematical subjects in secondary schools have been too strongly emphasized, and that these subjects should be made of greater real service to the student. To make these subjects of vital service to the student they must contribute greatly to the solution of his own problems of experience—they must help him to do what he is actually trying to do in shop work, in science, and so on. This seems to be the chief aim of the present volume.

The book attempts to work out the problem of unifying mathematics by relating arithmetic, algebra, geometry, and trigonometry to each other through their simultaneous use in the student's practical problems of the shops and laboratories. The modern real problem movement and the movement to unify the subjects of secondary-school mathematics have thus found a sane and practical realization in this new book.

That the book is teachable and that the problems are real and well chosen should result from the fact that the problem material and the organization are the outgrowth of several years of practical experience

in actual work along these lines by the author at Lewis Institute. It is especially worth noting that the method adopted in the earlier chapters requires the student to obtain his own data for many of his problems through measuring and weighing, and so on. This is educationally sound, and such sources of problem material should be used in secondary schools generally. In every school the text should be supplemented by problems of local origin and application.

Certain special features of the book are especially to be commended. Chapter I contains an excellent and timely treatment of "Measurement and Approximate Number." Most numbers encountered in practical life are approximate, but schools have not generally turned out students trained in handling such numbers in a common-sense way. The chapter on the use of squared paper is refreshing, and contains some features, such as the practical use of graphs in determining laws from data obtained by observation or experiment, that are new to secondary-school work. The use of modern graphic methods, as in real life, in the study of tables of values and in the solution of problems, is sanely made throughout the book, and shows how the graph may be used in a common-sense way in all mathematical work. Three chapters are devoted especially to unifying algebra and geometry, and teachers will find in the book many excellent problems on geometrical construction with algebraic applications and exercises for algebraic solution in plane and solid geometry.

Although this "Applied Mathematics" is especially adapted for use in technical schools and schools with practical shop and laboratory work, in any high school where it is possible to depart from traditional methods the book can be used as a supplementary text to make a beginning in the unification of mathematics and to make a test of work in applied problems. It will be found especially valuable as a source of supplementary practical problem material for use in teaching any of the mathematical subjects in the high school. Chapters I-VII may be used to substitute for much of the lifeless material usually given in first-year algebra courses; Chapters IX, X, and XII may be used in connection with plane geometry; and the problems of the other chapters may be used in connection with the study of advanced algebra or solid geometry.

Teachers will appreciate the several pages of excellent bibliography of works on elementary practical mathematics given at the end of the book. JAMES F. MILLIS.

Elementary Arithmetic. Pp vii+310. 15x19 cm. 1911. Complete *Arithmetic.* Pp. viii+404. 15x19 cm. 1911. *By Bruce M. Watson, Superintendent of Schools, Spokane, Wash., and Charles E. White, Principal of Franklin School, Syracuse, N. Y.* D. C. Heath & Co., Boston.

The *Elementary Arithmetic* is intended to cover the work usually done in the first five years of school. The material is well graded and the problems of play, of trade, and of industry are within the experience and knowledge of the child.

The *Complete Arithmetic* is designed for use in the grammar grades. It contains a brief and more thorough treatment of the topics included in the first book and the advanced subjects taught in the upper classes. Short and direct processes are used as far as possible, and each new topic is developed by means of oral exercises. These books should be examined by all teachers of arithmetic. H. E. C.

Revolving Vectors, by George W. Patterson, Ph.D., Professor of Electrical Engineering, University of Michigan. Pp. vi+89. 14x21 cm. 1911. Price, $1.00. The Macmillan Company.

The use of algebraic and geometric vector methods in the theory of alternating currents has been largely developed by Dr. Charles P. Steinmetz, and he has extended the application to include harmonic quantities. To make clear the distinction between vector and harmonic quantities, the author begins with the vector use and later considers the harmonic use of complex quantities.

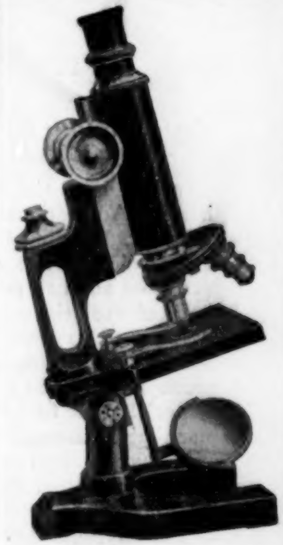
In the first two chapters the rotary power of roots of minus one and of imaginary exponents are discussed. In Chapter III the use of complex quantities is illustrated by the position of a point in a plane, uniform circular motion, and the effect of damping, spiral motion. Chapter IV makes use of vector expressions to represent simple harmonic quantities; harmonic electro-motive force; harmonic current, impedance; harmonic electro-motive forces in series; divided current, etc. In Chapter V the product of harmonic quantities is considered with special attention to the power of an electric current. Chapter VI gives applications to cases of currents which are not really harmonic. The closing chapters show how periodic currents which do not follow simple laws may be represented by revolving vectors, and discuss interlinked circuits.

H. E. C.

A Laboratory Manual of Physics for Use in Secondary Schools. By C. E. Linebarger, Lake View High School, Chicago. 175 pages. 21x25 cm. Paper, 1911. 90 cents. D. C. Heath & Co., Boston.

Every book must presumably justify its appearance as better than, or different from, any existing book on the subject. On this theory, Mr. Linebarger's Manual may lay claim to a right to live. It is a recent work, and therefore has the advantage of position in avoiding the errors of its predecessors. It has three features that deserve one's attention, the loose leaf notebook form, a large use of "general utility apparatus," and many optional features in connection with experiments. Like modern commercial ledgers, the loose leaf physics manual appears to be coming to stay, and the author tells us that "only a trial is needed to convince one of its points of superiority in laboratory instruction." Be that as it may, any attempt to solve the knotty problem of notebook care is welcome. The use of a "general utility board" in some dozen experiments is a simple yet effective way of answering the question of how to get the student to assume his rightful share in laboratory responsibility. In schools equipped with manual training tools, the making of the entire board from a drawing furnished is not only practicable, but a sure way of getting the boy interested in the subject by putting him to doing something he can do, and that will be necessary to his future laboratory work. Optional features are needed in every class to take care of rapid working or eager students who finish before the others, and who must be kept busy on pertinent work. The book has sufficient variety to enable one to offer variable work from year to year, and without the need of a completely equipped laboratory. Best of all, it represents the attempt of a fully competent teacher of long experience to show which of the many experiments offered in modern manuals are really of most worth in teaching physics.

T. L. H.



Nature Sketches in Temperate America, by Joseph Lane Hancock. Pp. 451. 16x23 cm. A. C. McClurg & Co. Chicago, 1911. $2.75.

In this book the author records his observations under the following heads: Adaptations in Plants and Animals, Protective Resemblance, Mimicry, Warning Colors. Animal Behavior, General Field Observations, and Ecology. The first chapter deals theoretically and historically with evolution and natural selection. As these headings indicate, much emphasis is given evolutionary matters. Many scientists will, no doubt, criticise the author for his implicit faith in the interpretations that are implied by the above chapter headings. With the exception of the first chapter, the work is based on out-of-door observations and contains much original material. The field observations are presented in such an interesting manner that the layman will enjoy the book, while at the same time they are scientifically accurate and are of much educational value. The most commendable part of the work is the excellent portrayal of animal behavior. The book contains over two hundred well executed drawings and photographic reproductions.

To give a better idea of the subjects discussed, following is a partial list of topics under, "Animal Behavior with Examples": The Assassin in Lace, The Ant-Lion, The Evening Primrose Spider Trap, The Behavior of a Jumping Spider, The Jug-making Wasp, The Habits of the White-Footed Mud-Dauber and Its Allies, The Hunted Cicada, An August Hailstorm with Its Sequence, Birds and Blue Racers, The Phoebe's Biography, The Red Squirrels' Frolics, Birdtime Reflections, Strange Mishaps to Birds, A Tragedy in the Dunes, Taking Spizella's Portrait.

C. W. F.

College Physics, by John Oren Reed and Karl Eugen Guthe, both of the University of Michigan. Pp. xxix+622. 15x22 cm. Cloth. 1911. $2.75 net. The Macmillan Company, New York.

It is indeed refreshing to one to be able to read and study such a text as this. The names of the authors are a sufficient guarantee of its accuracy. While the book was written primarily for use in their classes, it can be used with the classes in general physics in any college. In the preparation of this text the writers have kept in mind three fundamental principles which should be present in any physics text. They are: "to present the fundamental facts of the subject in clear, concise and teachable form; to relate these fundamental facts to the basic laws and to the theories of physics in such a way as to render plain the historical growth of the science; and to put the student in direct touch with first hand information concerning the epoch-making discoveries of the past, upon which the growth of the science has been based."

A knowledge of trigonometry is necessary for the thorough understanding of the 613 formulae. The text is presented in such a clear and interesting way that the student cannot help but be impressed with its statements, becoming possessed with the real worth of physics and having created in his mind a real desire to continue the study of the subject. The treatment of the matter is in the following order: mechanics, molecular mechanics, sound, heat, electricity and magnetism and light. There are sixty-four chapters, many of which close with practical problems bearing upon the work in the chapter. Numerous footnotes refer the reader to original papers. The leading paragraphs, of which there are 552, begin with bold face type. A complete index of ten pages is given. Mechanically this volume represents perfection in bookmaking.

C. H. S.